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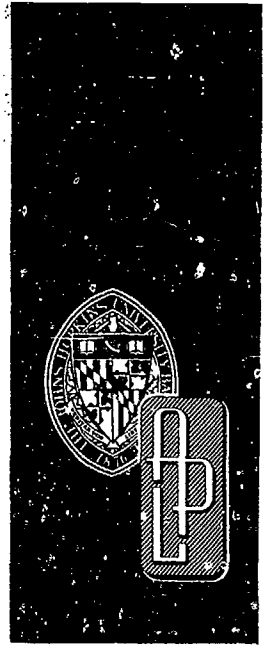

Technical Memorandum

MODIFICATIONS TO THE AEROTHERM CHARRING MATERIAL THERMAL RESPONSE AND ABLATION PROGRAM (CMA) FOR CARBON ABLATION ANALYSIS

C. C. CHAN

THE JOHNS HOPKINS UNIVERSITY ■ APPLIED PHYSICS LABORATORY

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Modifications to the Aerotherm Charring Material Thermal Response and Ablation Program (CMA) have been made to resolve deficiencies that were identified during the Aerospace Nuclear Safety Program's Galileo-VEEGA ablation studies. The primary modifications deal with integrating the Hunter carbon oxidation subroutine with the mainstream ablation calculations in CMA. The modified program uses a surface temperature criterion to determine when to switch between the Hunter oxidation subroutine and the sublimation routines in CMA. The user has the option to explicitly define this temperature criterion, indirectly define it via a mass loss parameter, or generate it via a search routine. A related feature uses Hunter's algorithm to compute an "ablation threshold temperature" of the material for switching between ablation and non-ablator routines. A secondary modification permits "blowing" to attenuate the shock layer radiation to a carbon surface.

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ABSTRACT

Modifications to the Aerotherm Charring Material Thermal Response and Ablation Program (CMA) have been made to resolve deficiencies that were identified during the Aerospace Nuclear Safety Program's Galileo spacecraft reentry/ablation studies for a Venus-Earth-Earth-Gravity-Assist (VEEGA) trajectory. The primary modifications deal with integrating the Hunter carbon oxidation subroutine with the mainstream ablation calculations in CMA. The modified program uses a surface temperature criterion to determine when to switch between the Hunter oxidation subroutine and the sublimation tables in CMA. The user has the option to explicitly define this temperature criterion, indirectly define it via a mass loss parameter, or generate it via a search routine. A related feature uses Hunter's algorithm to compute an "ablation threshold temperature" of the material for switching between ablation and non-ablator routines.

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SUMMARY

Improvements to the Aerotherm Charring Material Thermal Response and Ablation Program (CMA) code have been made to resolve deficiences that were identified during the Galileo spacecraft reentry/ablation studies for a Venus-Earth-Earth-Gravity-Assist (VEEGA) trajectory. They include several new algorithms to merge the Hunter carbon oxidation subroutine with the mainstream CMA ablation calculations.

A surface-temperature criterion is used for switching from the built-in surface thermochemistry tables to the Hunter subroutine. Three methods are available for the CMA user to define the temperature criterion. The first is a constant transition temperature criterion, the second is a constant mass loss parameter (β') criterion that is used to determine the transition temperature, and the last is a search for a temperature that gives the smoothest transition between the Hunter method and the surface thermochemistry tables in CMA (based on the slope differential between both ablation curves).

The modifications discussed in this report include use of the Hunter algorithm to compute an ablation threshold temperature of the material. The user may then choose either a constant temperature or use the Hunter algorithm to compute the temperature that corresponds to a negligible mass loss (i.e., no ablation).

INTRODUCTION

Problems with the CMA code that were experienced during the Galileo-VEEGA reentry/ ablation studies[1] showed clearly the need for modification to the code. The following modifications were subsequently recommended:

1. Increase the code's capacity for input data; specifically, to double the capacity of (a) the time dependent data table (i.e., the reentry environmental data), (b) the surface thermochemistry subtables (i.e., double the pressure tables and increase the entries per table), and (c) the nodes of the spatial grid (i.e., the structural model);
2. Merge Hunter's carbon oxidation algorithm[2] with the CMA code's mainstream ablation calculations;
3. Amend the Putz and Bartlett mass transfer correlation for blowing effects on convective heating;
4. Address the numerical characteristics of the surface energy balance in the diffusion-limited oxidation regime.

The code's capacity for input data (item 1 above) was completed previously. It was accomplished by identifying the appropriate arrays in the source code (Appendix A), increasing their dimension declarations, and recompiling the program. There was no descriptive memo generated for these minor modifications; however, the data set containing the source codes is listed in the catalog of IBM mainframe data sets for ANSP.[3]

More recent modifications to the CMA code will be discussed in this report and we will focus on the algorithms and their implementation. It will be assumed that the reader is familiar with the CMA code and graphite ablation theory. Detailed discussions on these topics can be found in Refs. 4 and 5, respectively.

The primary modifications are algorithms that merge the Hunter carbon oxidation subroutine with the mainstream CMA ablation calculations (item 2). Efficient use of the subroutine in CMA has been hindered by the lack of routines that integrate it with the mainstream CMA ablation calculations. The existing implementation only allows for the Hunter subroutine to be switched ON or OFF, meaning that if the mode of ablation changes from oxidation to sublimation or vice versa, a restart problem would be required.

Items 3 and 4 are future tasks. Work has started on modifying the Putz and Bartlett blowing option, but it is currently "on hold"; a list of the requirements for this task is provided herein for future reference. Some thoughts from the author on item 4 are included in this report.

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[1] D. W. Conn and C. C. Chan, "Preliminary Galileo-VEEGA Ablation Studies," JHU/APL BFD-2-87-001, EM-5392, March 12, 1987.

[2] L. W. Hunter, L. L. Perini, D. W. Conn, and P. T. Brenza, "Calculation of Carbon Ablation on a Re-entry Body During Supersonic/Subsonic Flight," *Journal of Spacecraft Rockets*, Vol. 23, No. 5, Sept.-Oct. 1986.

[3] C. C. Chan, "Catalog of ANSP Data Sets," JHU/APL BBE-LAM-7925, October 6, 1987.

[4] "User's Manual: Acrotherm Charring Material Thermal Response and Ablation Program, Version 3," Vol. 1, Acrotherm Report No. UM-70-14, April 1970.

[5] L. L. Perini, "Review of Graphite Ablation Theory and Experimental Data," JHU/APL ANSP-M-1, December 1971.

DISCUSSION

The new algorithms that have been added to the CMA code will now be discussed, but in order to follow the discussions on merging the Hunter subroutine, a brief background on the CMA ablation calculations is first provided. The CMA code computes values for the surface energy balance equation (Appendix B) using algorithms for either an ablating or a nonablating material. For the ablating material, the chemical and sensible energy components of the surface energy balance are computed using either (a) the Hunter subroutine (or the surface thermochemistry tables if the Hunter subroutine is not evoked) for oxidation ablation or (b) the surface thermochemistry tables for sublimation. For a nonablator, a simple surface energy balance with no mass transfer terms is solved. These stages of the ablation calculations are identified on the typical graphite ablation curve in Fig. 1. The natural logarithm of the material's mass loss parameter (β') is presented as a function of the wall surface temperature. The requirements of a merger routine are to determine the criteria for using ablation or nonablation calculations and oxidation or sublimation ablation calculations. These are illustrated in Fig. 1.

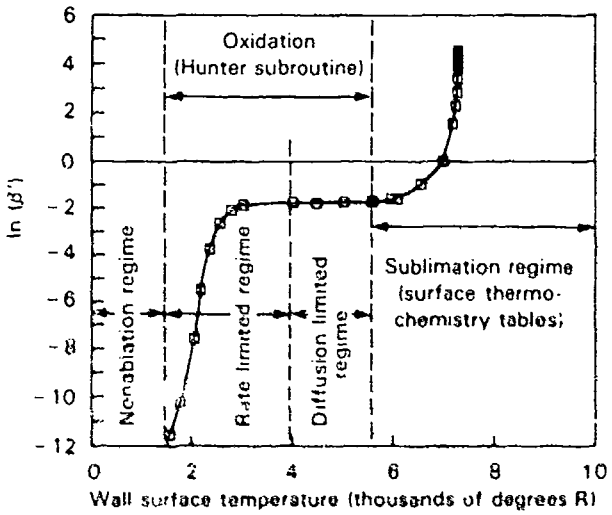

Figure 1 Graphite ablation curve at 1 psi.

Ablation Threshold Temperature

The switch from one to the other of the ablation or nonablation routines is triggered after comparing the surface temperature to a threshold temperature criterion. If the surface temperature is greater than the threshold temperature, then the ablating material routines are used for the surface energy balance; otherwise, the nonablating material routines are used. The previous implementation in CMA used in all cases the lowest temperature value from the ablation part of the surface thermochemistry tables for this criterion, which is inappropriate for the Hunter subroutine. The new implementation refines this process by using a rewritten form of the Hunter algorithm to compute the threshold temperature criterion that yields a negligible value of β' (0.00001). As an option, the user is also allowed to specify a fixed ablation threshold temperature. Implementation of this algorithm is in the partitioned data set 'BBE.CCC1.SOURCE.CMA5.PDS', members INPOUT4, CBM5, and FDTABC. The source code for these can be found in Appendix A.

Merging Hunter Subroutine With Mainstream Ablation Computations

During CMA ablation calculations, the Hunter subroutine or surface thermochemistry tables are used to compute β' and the chemical energy term of the surface energy balance equation, depending on the ablation mechanism. The Hunter subroutine is used for oxidation ablation, and the surface thermochemistry tables for sublimation. A switch from one to the other is based on a comparison of the wall-surface temperature to an "ablation transition temperature" criterion. The Hunter oxidation method is used whenever the material is ablating and the wall-surface temperature is less than the ablation transition temperature; otherwise, the surface thermochemistry tables are used.

The user is given three methods to define the transition temperature criterion for oxidation and sublimation calculations. First, a constant transition temperature may be specified by the user. This is the simplest and, computationally, least expensive implementation. Second, a constant mass loss parameter (β') may be specified by the user. This value of β' is used to interpolate a corresponding wall temperature from the surface thermochemistry tables, which will be used as the transition temperature. This option is slightly more expensive than the first option. Third, a search routine option may be employed. The search routine compares values of β' and its derivative from both the surface thermochemistry table and Hunter subroutine and finds the temperature with smallest differential between these values. This last option is the most expensive.

At the transition temperature, a step in the merged ablation curve may exist because the values of $\ln(\beta')$ computed using the Hunter subroutine and the surface thermochemistry tables do not necessarily agree (Fig. 2). This may prevent convergence of the surface energy balance near the transition temperature. This step is avoided by multiplying the oxidation ablation curve (of β' versus T_w computed

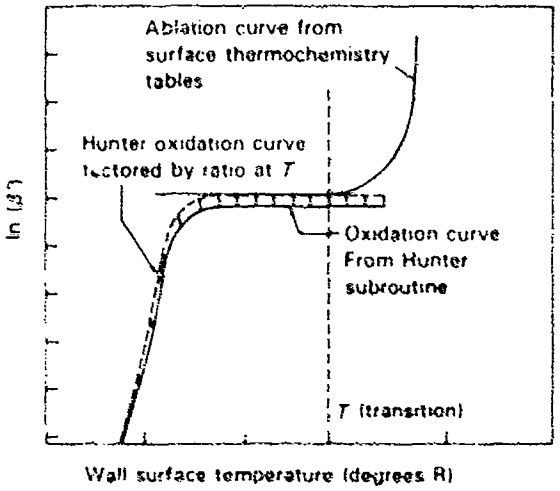

Figure 2 Merged ablation curve in modified CMA using surface thermochemistry tables and Hunter subroutine.

using the Hunter subroutine) by the ratio of the Hunter value and the surface thermochemistry table value at the transition temperature. The magnitude of this merge factor can be minimized by selecting a criterion that puts the transition temperature in the diffusion limited ablation regime.

Implementation of these algorithms is in the partitioned data set 'BBE.CCC1.SOURCE.CMA5.PDS', members INPOUT4, CBM5, MERGER, MERGE1, and MERGE2. The source code listings are in Appendix A.

Economy Feature

An economy feature that was added for use with the Hunter subroutine merger routines allows the user to specify the frequency of iteration steps at which the ablation threshold temperature, the oxidation-to-sublimation transition temperature criterion, and the merge factor are recomputed. For analysis cases using a trajectory with severe transients, the criteria should be recomputed at every iteration step. On the other hand, if the trajectory is long and has mild transients, recomputing every five iteration steps may be sufficient. If the user selects a frequency greater than one iteration per recomputation, a sample problem should be run to verify that the threshold ablation temperature and merge factor do not change drastically between iteration steps. Selecting higher frequencies will of course result in increased computing costs.

Code Validation

Several test problems were run to validate each of these options. Results from these problems were also compared to results from the previous version of the CMA code. The answers were consistent and in good agreement.

Usage

The executable program is stored in the partitioned data set 'BBE.CC1.LOAD.MODULES (CMAVO5)' on the mainframe computer. The new features are activated by a new input line at the end of the input file. This line must be present whether the new features are used or not. It follows the existing JTBL input parameter that is used to select the method for computing oxidation (i.e., to use the Hunter subroutine or the EST tables). If the new features are to be bypassed, the new input line should contain zeroes or blanks. A user's guide is provided in Appendix C, and a sample input file listing can be found in Appendix D.

FUTURE EFFORT

Future code improvement efforts will be devoted to amending the Putz and Bartlett mass transfer correlation for blowing effects on convective heating in CMA. They will also address iteration anomalies of the surface energy balance convergence scheme during ablation calculations in the diffusion limited regime.

Putz and Bartlett Blowing Correlation for Graphite

The existing implementation of the Putz and Bartlett blowing correlation for graphite ablation in CMA needs to be replaced with the actual equation from Ref. 4. CMA also needs to be modified to include the ability to calculate ablation when the Putz and Bartlett method predicts a "fully blown" boundary layer (i.e., when there is no convective heating). The following brief guideline is provided for future reference.

1. Install the Putz and Bartlett blowing correlation for range $0 < \beta_o' < 3$. The equations to be installed are presented in Appendix E. For Eq. (E.7), the molecular weight of gases at the wall (M_w) can be computed using the EST computer code,[6] and the molecular weight of gases at the edge of the boundary layer (M_e) can be approximated using the tables of gas composition behind a normal shock wave.
2. For the range of $\beta_o' > 3$ when the boundary layer is fully blown, D. W. Conn suggests* that the code be modified to include algorithms for a surface that is heated solely by shock layer radiation.

Surface Energy Balance Interation Procedure

During the Galileo-VEEGA reentry analysis, the surface energy balance equation in CMA did not converge in the material's diffusion-limited ablation regime. This is probably caused by the flatness of the ablation curve in this regime. We suggest a slight modification to the iteration scheme in order to achieve convergence.

First, some brief background information on the iteration scheme is needed. The CMA code uses a Newton-Raphson iteration scheme to solve the surface energy balance equation. The following equations summarize this.

$$\beta'_{i+1} = \beta'_i - e/(de/d\beta')$$

or

$$T_{i+1} = T_i - e/(de/dT) \ .$$

where

β'_i = mass loss parameter at the ith iteration,
β'_{i+1} = mass loss parameter at the $(i+1)$th iteration,
T_i = surface temperature at the ith iteration,
T_{i+1} = surface temperature at the $(i+1)$th iteration,
e = residual from iterating on surface energy balance equation,
$de/d\beta'$ = derivative of e with respect to β', and
de/dT = derivative of e with respect to T.

[6] K. E. Putz and E. P. Bartlett, "Heat Transfer and Ablation Rate Correlations for Re-entry Heat Shield and Nose-tip Application," AIAA 10th Aerospace Sciences Meeting, San Diego (Jan 17-19, 1972).

*Personal communication with the author.

Iteration terminates when the convergence criterion is satisfied. If convergence has not been satisfied within a given number of iterations, the criterion is doubled. Ultimately, if convergence does not occur within 50 iterations, or if successive iterations yield identical residuals, iteration terminates and the program continues execution using the values computed.

The author suspects that the adjustment term in the Newton-Raphson scheme is overshooting the converged value. Iteration might be improved by employing a relaxation factor (f_r) on the adjustment term:

$$\beta'_{i+1} = \beta'_i - e/(de/d\beta') \cdot f_r \ ,$$

where

$$0 < f_r < 1.0 \ .$$

Further investigation of the iteration process during diffusion-limited ablation calculations is needed.

CONCLUSION

Modifications discussed herein have been made to the CMA code that allow the Hunter algorithms to be used when the ablation mechanism is oxidation, and the surface thermochemistry tables to be used when the mechanism is sublimation. This is a dramatic improvement over the existing implementation of this subroutine because it eliminates the need for a restart problem whenever the ablation mechanism changes. These modifications have been installed around the existing code as options, meaning that the previous version of the code can be run by simply not evoking any of the new features.

REFERENCES

[1]D. W. Conn and C. C. Chan, "Preliminary Galileo-VEEGA Ablation Studies," JHU/APL BFD-2-87-001, EM-5392, March 12, 1987

[2]L. W. Hunter, L. L. Perini, D. W. Conn, and P. T. Brenza, "Calculation of Carbon Ablation on a Re-entry Body During Supersonic/Subsonic Flight," *Journal of Spacecraft Rockets,* Vol. 23, No. 5, Sept.-Oct. 1986.

[3]C. C. Chan, "Catalog of ANSP Data Sets," JHU/APL BBE/EAM-7925, October 6, 1987.

[4]"User's Manual: Aerotherm Charring Material Thermal Response and Ablation Program, Version 3," Vol. I, Aerotherm Report No. UM-70-14, April 1970.

[5]L. L. Perini, "Review of Graphite Ablation Theory and Experimental Data," JHU/APL ANSP-M-1, December 1971.

[6]K. E. Putz and E. P. Bartlett, "Heat Transfer and Ablation Rate Correlations for Re-entry Heat Shield and Nose-tip Application," AIAA 10th Aerospace Sciences Meeting, San Diego (Jan 17–19, 1972).

APPENDIX A

LISTING OF MODIFIED CMA SUBROUTINES

APPENDIX A

Listing of Modified CMA Subroutines

```
DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(ATM)'                          VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                    01/19/88 019 14:41:51

      SUBROUTINE  ATM(Z1,P1,T1,W1,A1,D1)
C  U.S. STANDARD ATMOSPHERE TO 700000 METERS.                              ATM
C  INPUT IS ALTITUDE IN FT (GEOMETRIC). OUTPUT IS,                         ATM
C     P1      PRESSURE                (LB/FT**2)                         ATM
C     T1      TEMPERATURE             (DEG. RANKINE)                     ATM
C     W1      MOLECULAR WEIGHT        (LB/LB-MOLE)                       ATM
C     A1      SPEED OF SOUND          (FT/SEC)                           ATM
C     D1      DENSITY                 (LB-SEC**2)/FT**4
      COMMON /ATMOT/ Z(22),TMB(22),R(21), PB(22),C1,C2,C3,
     1         C7,C8,ZM,RO,GM,GAM,RST,GO,PO,WO,G01
      Z1      =  C1*Z1                                                    ATM
      DO 1  I = 1, 22                                                     ATM
    1 IF (Z1.LT.Z(I)) GO TO 2
      I = 23
    2 I = I-1
      IF (I.EQ.0) I = 1
      A1      =  RO + Z (I)                                               ATM
      A2      =  RO + Z1                                                  ATM
      A3      =  Z (I)**2 - Z1**2                                         ATM
C     WRITE(6,500)I,Z1,Z(I),C1,A1,A2,A3
C 500 FORMAT(' **ATM** I,Z1,Z(I),C1,A1,A2,A3 = ',I3,6E12.5)
      IF (I.GE.9) GO TO 50
C  ALTITUDE BELOW  90000 METERS                                             ATM
      DH      =  (GM/GO)*((1./A1) - (1./A2)) + C7*A3/(2.*GO)              ATM
      T1      =  TMB(I) +(R(I)*DH/C2)                                     ATM
      W1      =  WO                                                       ATM
      A       =  GO*WO/RST                                                ATM
      DO 11 K = 1,3                                                       ATM
      J       =  -1 + 3*K                                                 ATM
   11 IF(I.EQ.J) GO TO 12
      P1  =  PB(I) *    ((TMB(I)/(TMB(I) +(R(I)*DH/C2)))**(A/R(I)))      ATM
      GO TO 200                                                           ATM
   12 P1  =  PB(I) * EXP ( - A*DH/(TMB(I)*C2))
      GO TO 200                                                           ATM
C  ALTITUDE  ABOVE  90000 METERS                                            ATM
   50 Z1 =    Z1/C2
      IF(Z1.GE.110.0) GO TO 51
      W1 =    17.98 + 0.239*Z1 - 0.0013*(Z1**2)
      GO TO 53
   51 IF (Z1.GT.170.0) GO TO 57
      W1 =   -.41873644E+02  + .22496378E+01*Z1 - .25825938E-01*(Z1**2)
     1       +.12705198E-03*(Z1**3) - .22989608E-06*(Z1**4)
      GO TO 53
   57 W1 =   +.28312068E+02  + .11190901E-01*Z1 - .18061034E-03*(Z1**2)
     1       +.31829429E-06*(Z1**3) - .16924926E-09*(Z1**4)
   53 Z1 =  Z1*C2
      TM =  TMB(I)  + (R(I)*(Z1 - Z(I))/C2)
      T1      =  (W1/WO)* TM                                              ATM
      A4      =  -Z(I) + (  TMB(I)*C2/R(I))                               ATM
      A5      =  WO*C2/(R(I)*RST)                                         ATM
      A6      =  Z(I)  + A4                                               ATM
      A7      =  Z1    + A4                                               ATM
      A8      =  RO    - A4                                               ATM
      A9      =  ((Z(I) - Z1)/(A1*A2)) +(1./A8)*ALOG(A7*A1/(A6*A2))       ATM
      A10     =   (Z(I) - Z1) + A4*ALOG(A7/A6)
      A11     =  (-(GM/A8)*A9 - C7*A10)*WO/(R(I)*RST)                     ATM
      P1      =  PB(I)*EXP (A11)
```

```
C     WRITE(6,501)W1,TM,T1,P1,G01
C 501 FORMAT(' **ATM** W1,TM,T1,P1,G01 = ',5E12.5)
C PRESSURE,TEMPERATURE AND MOLECULAR WEIGHT FOUND.                    ATM
  200 P1 = P0*P1                                                      ATM
      Z1 = Z1/C1                                                      ATM
      T1 = T1*C3                                                      ATM
      A2 =  RST*105.86126/W1                                          ATM
      A1      =  SQRT  (GAM*A2*T1*G0*C8)
      D1 = P1/(A2*T1*G01)
C     WRITE(6,502)P1,Z1,T1,A2,A1,D1
C 502 FORMAT(' **ATM** P1,Z1,T1,A2,A1,D1 = ',6E12.5)
      RETURN                                                          ATM
      END                                                             ATM
```

```
DSNAME = 'BBE.CCC1.SOURCE.CMA5.PDS(CBM5)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/28/88 028 13:10:38

      SUBROUTINE CBM
C     CHARRING MATERIAL THERMAL RESPONSE AND ABLATION PROGRAM ALLOWING  CBM    2
C     FOR UP TO FIVE DECOMPOSING BACK-UP MATERIALS                      CBM    3
C       AEROTHERM CORPORATION     RM KENDALL  C MOYER                   CBM    4
C
C     CHANGES TO PROGRAM:
C     (1/16/87) SIZE OF THI,THE,TQR,TCM,TBRP,TALT,TVEL,TPI
C               EXPANDED TO 120 ELEMENT ARRAYS
C     (1/19/87) SIZE OF TSEN,THSEN,TCPSEN,TLMC,TTS,TCHEM,TBPF,
C               TPR,NMG,TMG,NLO,NHI,KHI,ISEN,
C               EXPANDED TO ACCOMMODATE 20 EST TABLES WITH 30
C               ENTRIES EACH
C
C     (1/29/87) ALL OTHER SUBSCRIPTED VARIABLE DIMENSIONS DOUBLED
C               AS RECOMMENDED BY L.L. PERINI.
C
      COMMON KOUT,IEX,DEN,VR                                            CBM    5
      COMMON THI(76),TLO(76),TR(76),TT2(60,20),TCP(60,20),TKP(60,20),THZCBM    6
     1(60,20),TEP(60,20),TTH(120),THE(120),TQR(120),TCM(120),TT1(60)    INPOU  4
     2,THG(60),DH12(4),RECORD(108),SO(40),RHO(20),TEPBF(60,20)
      COMMON MATL(101),DEL(101),TA(101),H(101),RC(101),RA(101),
     1AREA(101),EMA(101),RAV(101),LGAP(101),QGEN(101),GAP(101)
      COMMON ROA(1000),ROB(1000),ROC(1000)                              CBM    12
      COMMON TPR(20),NMG(20),
     C                    TMG(5,20),NLO(5,20),NHI(5,20),KHI(5,20),
     1 TTSEN(30,20),THSEN(30,20),TCPSEN(30,20),TLMC(30,5,20),ISEN(20),
     2 TPI(120),  TTS(30,5,20),TCHEM(30,5,20),VFZ,CMH,TBPF(30,5,20),
     3 NPR,NGS
      COMMON ICT,NPC,II,NBM,NUMN,NL,DELHG,DELM,RFT,RHORA,RHORB,RHORC,TRACBM    18
     1CA,TRACB,TRACC,RHOOA,RHOOB,RHOOC,EA,EB,EC,BA,BB,BC,PSIA,PSIB,PSIC,CBM    19
     2TRACM,PET,PETE,RSV,ETA,DTPR3,DTPR2,DTPRT,TPR3,TPR2,THZRO,THFIN,WT,CBM    20
     3TMWT,GAMA,OMG,NO,FJEH,FJFS,JF,JFHP,JFH,INPUT,     DTHIN,BRP,HCONV,CBM    21
     4EPSW,TRES,INCH,DTHB,NN,NI,NOI,CHCRI,PYCRI,TBRP(120),NR,
     5 TX(30,6),F1(30,6),F2(30,6),NCON,NBPF,NFIS,BREX,SWELL
      COMMON BBB(10,6),EE(10,6),FF(10,6),PSI(10,6),RHOO(10,6),          CB
     XRHOR(10,6),
     1ROCOM(50,3),DHC(10),DHV(10),RHOC(10),RHOV(10),P(10),PP(10),
     XTREF(10),
     2GA(10),OMGA(10),NFI(10),NLA(10),TT5(60,20),TENT(60,20),
     XTKBU(60,20),
     3TCBU(30,10),X(101),NDBU,NBM2,TRAC(10,6),NBUFT(10),KNST,IBUG,TBUG,
     4 TALT(120),TVEL(120),RRGAP(101),AGAP(101),TCOND,IEROS,ISR,
     5 NGC1,NGC2,NGC3,NGC4,TCON1(101),TCON2(101),TCON3(101),TCON4(101),
     6 COND1(101),COND2(101),COND3(101),COND4(101),
     7 THCONV(101),TEPSW(101),TTRES(101),TQ(101),TEPSD(101),IBF,TL,THD,
     8 JTBL,IDRD,RHOCI(201),DTDT(201),RA1,RA2,RA3
      COMMON/OTPT/CPE(6),EMO(201),DEP(20,10),CNC(101),CN(101),Y1(4),
     1 CNO(101),TO(20),RO(101),NISO(20),BR,CH,GS,SA,TB,TT,ASU,CMD,CMT,
     2 ITS,QRP,RAD,RA1(101),RSU,CMDM,CMMT,DCDT,DEDT,DIDT,DPDT,ITER,KSCT,
     3 PGPU,PRES,QRPT,RADT,SNET,DECOM,DEDTT,DSDTB,PGPUT,QCHEM,QCOND,
     4 QCONV,QLOSS,SDNET,       SUMQE,TIPRT,TSAVE,VELFS,DECOMT,
     5 PRSATM,QCHEMT,QCONDT,QCONVT,QLOSST,KK,RR(101),DHDG(101),
     6 RON(101),ROT(101),DNCP(6),DRO(6),D1(4),FA,FB,FC,DTH,DTHC,DSI,
     7 DTA,GSM,COLD,GSMS,GSMT,GSM2T,DSDT,POLD,TH,AFTFS,DSDTT,
     8 TEMP,BE,LL,LU,HL,HW
      COMMON/MERGE/VRM,VRP,IMG,IPR,I1,I3
      COMMON/OPTION/TCRIT,RPCRIT,TABCN,IOPTN,IMSG,MITER,IBLOPT
```

```
      COMMON/BLOWIN/BLOW,BLOFAC
      INTEGER FFLAG,FFLAG1
      EQUIVALENCE (DH1,DH12(1)),(DH2,DH12(2)),(TS,TA(1))
      DIMENSION VITER(101),EITER(101),EMISF(200),RATG(200),Y2(48),D2(48)
     1,Y3(16),D3(16),CPC(101),CPV(101),CP(101),HP(101),HC(101),A(101),
     2 B(101),C(101),D(101)
  529 FORMAT(17H  ITERATION STOP  )                                    CBM   50
  542 FORMAT(/33X14H----OUTPUT----)                                    CBM   51
  582 FORMAT(6E15.7)
 5601 FORMAT(1015)                                                     BUG
 5602 FORMAT(7E17.7)
 5603 FORMAT(6E17.7)
 7043 FORMAT(16,4F10.6)
C                                                                     CBM   106
C                                                                     CBM   107
      DNCP(3)=99999.                                                  CBM   108
      NMGX=NMG(1)
      KSCT=3
      SIG=.481E-12                                                    CBM   110
C     CHAR AND PYROLYSIS ZONE CRITERIAL DENSITIES                     CBM   111
      DNCP(1)=RHO(2)+CHCRI*(RHO(1)-RHO(2))                            CBM   112
      DNCP(2)=RHO(2)+PYCRI*(RHO(1)-RHO(2))                            CBM   113
C                                                                     CBM   114
C     INITIAL VALUES FOR TIME LOOP                                    CBM   115
C                                                                     CBM   116
C ----- INITIAL FACTOR FOR DIKI-TO-TABLES MERGE ROUTINE & BLOWING
      FACTOR=-1.0
      FFLAG=0
      FFLAG1=0
      BLOFAC=1.0
C -----
      ITER=-1
      DTHC=DTHB                                                       CBM   118
      IAB=0                                                           CBM   119
      RSU=ABS(RSV)                                                    CBM   127
      CMFL=0.0                                                        CBM   129
      DSDTM = 0.0
      SOEGR=0.                                                        CBM   157
      GSEGR=0.                                                        CBM   158
      EGO=0.                                                          CBM   161
      HW=0.                                                           CBM   162
      TH=THZRO                                                        CBM   165
      THDS=THZRO-DTHIN                                                CBM   167
      THPRT=TH                                                        CBM   168
      VRM = 0.0
      CMDL = 0.0
      IRB = 0
      IRD = 0
      I2 = 0
      I4 = 0
      TOLER = 1.0
      I1 =1
        DO 4101 I = 1,NUMN
        RATG(I) = 0.0
 4101   EMISF(I) = 0.0
      REWIND KSCT                                                     CBM   169
      CALL LCOUNT (-2,LCI,NPG)
      WRITE (KOUT,542)                                                CBM   171
C     ----- TIME INCREMENT
      DTH=DTHIN                                                       CBM   173
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```
C     ----- NODE THICKNESS OR MINIMUM ALLOWABLE THICKNESS
      DELGR=AMIN1(DEL(1),DELM)/5.0                                        CBM  174
C     ----- NODAL TEMP. FROM PREVIOUS TIME STEP
      TSAVE=TA(1)+1.0                                                     CBM  175
      FA=(1.-PSIA)*BA*(RHOOA**(1.-PSIA))                                  CBM  176
      FB=(1.-PSIB)*BB*(RHOOB**(1.-PSIB))                                  CBM  177
      FC=(1.-PSIC)*BC*(RHOOC**(1.-PSIC))                                  CBM  178
C     ----- EXPONENT TO ADJ. CONVECTION DUE TO ABLATIVE RADIUS CHANGE
      REX = BREX
C                                                                         CBM  180
C     BEGINNING OF TIME LOOP                                              CBM  181
C                                                                         CBM  182
C     NL = LAST ABLATING NODE
C     THFIN = TIME AT END OF PROBLEM
C     THPRT = OUTPUT TIME
C
  410 IF(NL.GT.1) GO TO 7412
      THFIN = TH
      THPRT = TH
 7412 ITER = ITER + 1
      IF(IBUG.NE.0) WRITE(6,5601) ITER,NL,ND8U,NBM2,NUMN,JFHP ,NCON,      BUG
     1 NFIS                                                               BUG
C                                                                         CBM  184
C     CALCULATION OF NODAL PROPERTIES                                     CBM  185
C                                                                         CBM  186
C     ISR = 1; NO SURFACE RECESSION OPTION
C     ISR = 0; SURFACE RECESSION ALLOWED
C     DSI = SURFACE RECESSION DURING TIMESTEP; INITIALIZED
C           IN BLOCK COMMON
C
      IF(ISR.NE.0) DSI=0.0
C     ----- NODAL LOCATIONS FROM SURFACE
        DO 108 N=2,NL                                                     CBM  187
  108   RA(N-1)=RA(N-1)+DSI                                               CBM  188
      RA(NL)=RA(NL)+DSI/2.                                                CBM  189
C     ----- RR = CROSS-SECTIONAL AREA OF NODE
      CALL OGLE(NL,RA,RR,NUMN,RAV,AREA,EMA)                               CBM  190
      ASU=RR(1)                                                           CBM  191
      J=1-JFH-JF                                                          CBM  192
C
C     PROCESS ABLATING NODE PROPERTIES
C
C     CN(N),CNC(N) = THERMAL CONDUCTIVITY OF PLASTIC AND CHAR
C     CPV(N),CPC(N) = SPECIFIC HEAT OF PLASTIC AND CHAR
C     HP(N),HC(N) = SENSIBLE ENTHALPY OF PLASTIC AND CHAR
C     RO(N),ROT(N) = DENSITY AND TOTAL DENSITY
C     X(N) = WEIGHTING FACTOR FOR PARTIALLY PYROLYZED MATERIAL
C     RAT(N) = THERMAL RESISTANCE; DL/(K*A)
C     GAMA = VOLUME FRACTION
C
      DO 105 N=1,NL
      J=J+JF                                                              CBM  194
      RR(N)=RR(N)/ASU                                                     CBM  195
      CALL LOOK (3,TA(N),H2,TCP,TKP,THZ,0,Y2,Y2(4),3)                     CBM  196
C     ----- VIRGIN PLASTIC MATERIAL
      CN(N)=Y2(2)                                                         CBM  197
      CPV(N)=Y2(1)                                                        CBM  198
      HP(N)=Y2(3)+DH1                                                     CBM  199
      CALL LOOK (4,TA(N),H2(1,2),TCP(1,2),TKP(1,2),THZ(1,2),0,Y2,D2,3)    CBM  200
C     ----- CHAR MATERIAL
```

```
      CNC(N)=Y2(2)                                                        CBM  201
      CPC(N)=Y2(1)                                                        CBM  202
      HC(N)=Y2(3)+DH2                                                     CBM  203
C     ----- SELECT MATERIAL TYPE
      IF (MATL(N)-1) 103,101,102                                          CBM  204
C     ----- MAIN MATERIAL VIRGIN PLASTIC
  101 X(N)=1.                                                             CBM  205
      CP(N)=CPV(N)                                                        CBM  206
      H(N)=HP(N)                                                          CBM  207
      RO(N)=RHO(1)                                                        CBM  208
      ROT(N)=RHO(1)                                                       CBM  209
      GO TO 105                                                           CBM  210
C     ----- MAIN MATERIAL CHAR
  102 X(N)=0.                                                             CBM  211
      CN(N)=Y2(2)                                                         CBM  212
      H(N)=HC(N)                                                          CBM  213
      CP(N)=CPC(N)                                                        CBM  214
      RO(N)=RHOCI(N)
      ROT(N)=RHOCI(N)
      GO TO 105                                                           CBM  217
C     ----- MAIN MATERIAL PYROLYSIS ZONE
  103 X(N) = RHO(1)*(1.0-RHOCI(N)/RO(N))/(RHO(1)-RHOCI(N))
      H(N)=X(N)*HP(N)+(1.-X(N))*HC(N)                                     CBM  219
      CP(N)=X(N)*CPV(N)+(1.-X(N))*CPC(N)                                  CBM  220
      K = J
      IF(N.EQ.1) K=1
C     ----- RESIN FILLER DENSITY FROM MATERIAL A, B, C
      ROT(N)=(ROA(K)+ROB(K))*GAMA+OMG*(ROC(K))
  105 CONTINUE
      IF (ITER.LE.0)
     1RAT(NL)=DEL(NL)/(RR(NL)*(CN(NL)*X(NL)+CNC(NL)*(1.0-X(NL))))
      IF(NDBU.LE.0) GO TO 7413
C
C     DECOMPOSING BACKUP MATERIAL PROPERTIES
C
      DO 740  L=1,NDBU
         LL=NFI(L)                                                        CBM  231
         LU=NLA(L)                                                        CBM  232
      N=2*L-1                                                             CBM  233
      DO 741    I=LL,LU                                                   CBM  234
      CALL LOOK(20+2*L,TA(I),TT5(1,N),TCBU(1,N),TKBU(1,N),TENT(1,N)       CBM  235
     C    , 0,Y2,D2,3)                                                    CBM  236
         CN(I)=Y2(2)                                                      CBM  237
         CPV(I)=Y2(1)                                                     CBM  238
         HP(I)=Y2(3)+DHV(I)                                               CBM  239
      CALL LOOK(21+2*L, TA(I), TT5(1,2*L), TCBU(1,2*L), TKBU(1,2*L),      CBM  240
     C    TENT(1,2*L), 0,Y2,D2,3)                                         CBM  241
         CNC(I)=Y2(2)                                                     CBM  242
         CPC(I)=Y2(1)                                                     CBM  243
         HC(I)=Y2(3)+DHC(I)                                               CBM  244
         H(I)=X(I)*HP(I)+(1.0-X(I))*HC(I)                                 CBM  245
         RR(I)=AREA(I)/ASU                                                CBM  246
      IF(ITER.NE.0) GO TO 741
      RO(I)=X(I)*RHOV(I)+(1.0-X(I))*RHOC(I)
      RON(I)=RO(I)                                                        CBM  249
      RAT(I)= DEL(I)/(RR(I)*(CN(I)*X(I) + CNC(I)*(1.0 -X(I))))            CBM  250
  741    CP(I)=X(I)*CPV(I)+(1.0-X(I))*CPC(I)                              CBM  251
  740 CONTINUE                                                            CBM  252
 7413 IF (NUMN.LT.NBM2) GO TO 112
      RRGAP(NL) =  AGAP(NL)/ASU
```

```
C
C       NON-DECOMPOSING BACKUP MATERIAL PROPERTIES
C
        DO 107 N=NBM2,NUMN
        RR(N)=AREA(N)/ASU                                                  CBM  255
        RRGAP(N)  =  AGAP(N)/ASU
        KT=MATL(N)                                                         CBM  256
        CALL LOOK(KT+2,TA(N),TT2(1,KT),TCP(1,KT),TKP(1,KT),0,0,Y2,D2,2)    CBM  257
        CP(N)=Y2(1)                                                        CBM  258
        CN(N)=Y2(2)                                                        CBM  259
C       ------ THERMAL RESISTANCE
        RAT(N)=DEL(N)/(CN(N)*RR(N))                                        CBM  260
  107   RO(N)=RHO(KT)                                                      CBM  261
C
C       GAP RESISTANCES
C
        DO 106 N =NL,NUMN
        RATG(N) = 0.0
        EMISF(N) = 0.0
        KX = NBM2
        IF(N.EQ.NL) GO TO 747
        KX = N+1
        IF(N.LT.NBM2) GO TO 106
  747   IF(LGAP(N).EQ.0) GO TO 106
        TDUM = (TA(N)+TA(KX))/2.0
        IF (LGAP(N).EQ.1) HA = PIF1(TDUM,TCON1,NGC1,COND1)
        IF (LGAP(N).EQ.2) HA = PIF1(TDUM,TCON2,NGC2,COND2)
        IF (LGAP(N).EQ.3) HA = PIF1(TDUM,TCON3,NGC3,COND3)
        IF (LGAP(N).EQ.4) HA   PIF1(TDUM,TCON4,NGC4,COND4)
C   HELIUM CONDUCTIVITIES P-1ATM
        IF (LGAP(N).EQ.6) HA = 1.0E-6*EXP(5.955-8153.0/(2454.0+TDUM))
        IF (LGAP(N).EQ.7) HA = 0.0
        IF (LGAP(N).NE.5) GO TO 746
C     YOS - P = 1 ATM
        IF(TDUM.GT.3000.0) HA = 1.0E-6*
       1                        EXP(10.116-103176.0/(10941.0+TDUM))
C     NBS - P = 1 ATM
        IF(TDUM.LE.3000.0)
       1HA=3.167E-7*
       2            SQRT(TDUM)/(1.0+441./*(10.0**(-21.6/TDUM))/TDUM)
  746   KT = MATL(N)
        CALL LOOK(KT+2,TDUM ,TT2(1,KT),TEPBF(1,KT),0,0,0,Y2,D2,1)
        EM1 = Y2(1)
        KT = MATL(N+1)
        CALL LOOK(KT+2,TDUM ,TT2(1,KT),  TEP(1,KT),0,0,0,Y2,D2,1)
        EM2 = Y2(1)
        FE = 1.0/(1.0/EM1 + 1.0/EM2 - 1.0)
        RATG(N) = HA*RRGAP(N)/GAP(N)
        EMISF(N) = 1.0/STG/FE/RRGAP(N)
        IF(IBUG.NE.0) WRITE(6,5602) EM1,EM2,HA,FE,RR(N),GAP(N),TDUM,
       1    RRGAP(N) ,AGAP(N)
  106   CONTINUE
C
C       BACK WALL HEAT TRANSFER USING TIME TABLES - LLP,SEPT,1975.
C
C       TH = CURRENT TIME
C       TQ = TABLE TIME VALUES
C       THCONV = B.W. CONVECTION COEFFICIENT
C       TEPSW = B.W. EMMISIVITY TO SPACE
C       TEPSD = B.W. EMMISIVITY TO RESERVOIR
```

```
C       TTRES = RESERVOIR TEMPERATURE
C       HRES = TOTAL HEAT TRANSFER COEFFICIENT AT BACKWALL
C       DEL = NODE THICKNESS
C       QLOSS = B.W. HEAT FLUX
C       QLOSST = TIME INTEGRATED B.W. HEAT FLUX
C       CMT = AMOUNT OF CHAR ABLATION
C       CMMT = TIME INTEGRATED CHAR ABLATION
C       DTH = TIME INCREMENT
C       DTS = CHANGE IN SURFACE TEMPERATURE
C
  112 EPSW = PIF1(TH,TQ,IBF,TEPSW )
      EPSD = PIF1(TH,TQ,IBF,TEPSD)
      TRES = PIF1(TH,TQ,IBF,TTRES )
      HCONV= PIF1(TH,TQ,IBF,THCONV)
      HRES=SIG*EPSW*(TA(NUMN)+TRES)*(TA(NUMN)**2+TRES**2)+HCONV
     1 +SIG*EPSD*TA(NUMN)**4/(TA(NUMN)-TRES)
      RAT(NUMN+1)=2./(HRES*RR(NUMN)+.00000001)
      QLOSS = 0.0
      IF(HRES.NE.0.0)
     1QLOSS=(TA(NL)-TA(NBM))/(0.5*(RAT(NL)+RAT(NBM))+RC(NL)/RR(NL))
      QLOSST=QLOSST+QLOSS*DTH/AREA(1)*ASU                                  CBM  265
      CMT=CMT+RHO(2)*DSDTB*ASU/AREA(1)*DTH
      CMMT = CMMT + RHO(2)*DSDTM*ASU/AREA(1)*DTH
      DEL(NUMN + 1) = CN(NUMN)/(HRES + 0.00000001)                         CBM  267
      RR(NUMN+1)=RR(NUMN)                                                  CBM  268
      DTHS=DTH                                                             CBM  269
      DTS=TSAVE-TA(1)                                                      CBM  270
      IF(IBUG.NE.0) WRITE(6,5602) (RAT(I),RO(I)        ,RATG(I),           BUG
     1 EMISF(I),CP(I),CN(I),TA(I),I=1,NUMN)                                BUG
      IF(ITER.EQ.0) GO TO 606
C                                                                          CBM  272
C     OUTPUT                                                               CBM  273
C                                                                          CBM  274
C     JJJ = 1; MEANS LAST ITERATION COMPLETED
C
C
      IF(TH-THPRT.LT.-0.00001) GO TO 4410
 3000 JJJ=0
      CALL OUTPT(JJJ)
      IF (JJJ.EQ.1) GO TO 1
C     ---------- COMPUTE TIME STEP (DTH) & CURRENT TIME (TH)
 4410 DTH=AMIN1(DTHB,DELCH/(DSDTB+.0000001),TH-THDS, 50.0/(ABS(TSAVE-TA(CBM  434
     11))+.1)*DTH)                                                         CBM  435
      TSAVE=TA(1)                                                          CBM  436
      DTH=(THPRT-TH)/(AINT((THPRT-TH)/DTH+1.0001))
      TH=TH+DTH
      IF(TH.GT.TBUG) IBUG=1
C     ---------- FUNCTIONS OF TIME
  606 I=IR(1)                                                              CBM  441
      VF=VFZ                                                               CBM  442
  601 IF(TTH(I+1).GE.TH-0.00001) GO TO 604
      IF(I+1.GE.IHI(1)) GO TO 604
      I=I+1
      IF (TTH(I+1).NE.TTH(I)) GO TO 601
      TH=TH-DTH
      THDS=TTH(I)-DTHIN                                                    CBM  448
      DTH=AMAX1(DTHIN,TTH(I)-TH)                                           CBM  449
      TH=TH+DTH                                                            CBM  450
      GO TO 601                                                            CBM  451
C
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```
C     TIME DEPENDENT VALUES FROM TABLE
C
C     DEN = INTERPOLATION RATIO
C     CH = HEAT TRANSFER COEFFICIENT (RUCH)
C     QRA = RADIATION FLUX TO SURFACE (OPTION 1 & 3) OR
C           RECESSION (OPTION 2)
C     PRES = NATURAL LOGARITHM OF PRESSURE
C     HE = RECOVERY ENTHALPY
C     BRP = BLOWING REDUCTION PARAMETER, LAMBDA
C     VELFS = VELOCITY
C     AFTFS = ALTITUDE
C
  604 DEN=(TH-TTH(I))/(TTH(I+1)-TTH(I))                                  CBM  452
      IF (TTH(I+1).LE.TTH(I)) DEN=0.0
      CH=TCM(I)+DEN*(TCM(I+1)-TCM(I))
      QRA=TQR(I)+DEN*(TQR(I+1)-TQR(I))                                   CBM  456
      PRES=TPI(I)+DEN*(TPI(I+1)-TPI(I))                                  CBM  457
      HE=THE(I)+DEN*(THE(I+1)-THE(I))                                    CBM  458
      BRP=TBRP(I)+DEN*(TBRP(I+1)-TBRP(I))                                CBM  459
      VELFS = TVEL(I) + DEN*(TVEL(I+1)-TVEL(I))
      AFTFS = TALT(I) + DEN*(TALT(I+1)-TALT(I))
C     ---------- SELECT PROBLEM OPTION (1,2 OR 3)
      IF(IBUG.NE.0) WRITE(6,5602) TH,CH,QRA,PRES,HE,BRP,ASU,VELFS,AFTFS
      II=1                                                               CBM  460
      IF(CH.GT.0.0) GO TO 600
      II=2
      CH=0.0                                                             CBM  463
      IF(HE.GT.2.0) GO TO 600
      II=3
      VF=HE                                                              CBM  466
      HE=0.                                                              CBM  467
  600 IR(1)=I                                                            CBM  468
      IF(ITER.NE.0) GO TO 610
      DEDT=0.
      ITER=1                                                             CBM  471
      GO TO 3000                                                         CBM  472
C
C     DECOMPOSITION (PYROLYSIS OR CHARRING)
C
  610 IF(DTH.GT.0.000001) GO TO 608
      WRITE (KOUT,582) TH,DTH,DTHS,DTHB,THDS,DTS,DELCR,DSDTB
      TH=THFIN                                                           CBM  475
      GO TO 3000                                                         CBM  476
C                                                                        CBM  477
  608 CALL DECOMP
C                                                                        CBM  711
C     CALCULATION OF IMPLICIT TEMPERATURE COEFFICIENTS FOR IN-DEPTH      CBM  712
C     ENERGY EQUATION MATRIX AND INTERNAL ENERGY RATE TERMS              CBM  713
C                                                                        CBM  714
C
C     IMIN = INTEGER ZERO
C     NLM = NL - 1
C     NL = LAST ABLATOR NODE
C     GSM = ACCUMULATED PYROLYSIS GAS FLOW RATE ENTERING A NODE
C     DMDG = ACCUMULATED PYROLYSIS GAS GENERATION IN A NODE PER UNIT
C            AREA AND TIMES NO. OF NODELETS PER NODE, FINALLY ADJUSTED
C            TO AMOUNT OF PYROLYSIS GAS GENERATION IN A NODE.
C     DRODTD = TOTAL RATE OF CHANGE OF DENSITY AT CONSTANT Y FOR
C              CURRENT NODE
C     DSDT = SURFACE RECESSION
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C     RR = NORMALIZED CROSS-SECTIONAL AREA OF NODE
C     DEL = NODE THICKNESS
C     DVB = CONDUCTIVITY PARAMETER
C     X1 = WEIGHTING VARIABLE
C     PETE = DENSITY TERM
C     PET = DENSITY FACTOR
C     RAT = CONDUCTION RESISTENCE, DL/KA
C     CP1 = SPECIFIC HEAT AT TOP NODE
C     CP = SPECIFIC HEAT AT A NODE
C     CPGAS = SPECIFIC HEAT OF PYROLYSIS GAS
C     H1 = ENTHALPY AT TOP NODELET IN A NODE
C     HBAR = TEMP. DEPENDENT REACTION ENTHALPY
C     HGAS = ENTHALPY OF PYROLYSIS GAS
C     GSEGR = ENERGY TERM, SUM OF HGAS*DMDG OVER NODES
C     SOEGR = TERM HGAS*DMDG, SUMMED OVER ALL NODES
C     EGO = ENERGY LEAVING SURFACE WITH PYROLYSIS GAS
C     HW = ENTHALPY OF EDGE GASES AT WALL TEMPERATURE (OPTION 1)
C          OR ENTHALPY OF PYROLYSIS GASES AT WALL TEMP (OPTION 3)
C     ROT = DENSITY OF TOP NODELET IN A GIVEN NODE
C     RC = CIRTACT RESISTENCE BETWEEN NODE AND NEXT NODE DOWN
C     RON = NEW DENSITY OF A NODE
C     RO = OLD DENSITY OF A NODE
C
      DVB=0.                                                          CBM  715
      SOEGR=0.                                                        CBM  716
      GSEGR=0.                                                        CBM  717
      TB=0.                                                           CBM  718
      RAT(1)=2.*RAT(1)                                                CBM  719
      CPNL=CP(NL)                                                     CBM  720
      NLM=NL-1                                                        CBM  721
      IMIN=0                                                          CBM  722
      DSXX = DSDT
      IF(ISR.NE.0) DSDT = 0.0
C     ---------- ABLATING NODE COEFFICIENTS EXCEPT LAST NODE
      DO 30 I=IMIN,NLM                                                CBM  723
      IF(I.LE.0) GO TO 15
      GSM=GSM-DMDG(I)
      DRODTD=-DMDG(I)/(RR(I)*DEL(I))                                  CBM  726
      FACT1=DTH/(DEL(I)*RR(I))                                        CBM  727
      FACT2=GSM/(DEL(I)*RR(I))                                        CBM  728
      A(I)=-FACT1*DVB                                                 CBM  729
      DVB=1.0/(0.5*(RAT(I)+RAT(I+1))+RC(I)/RR(I))                     CBM  730
      TERM2=RON(I)*CP(I)-DTH*(CPGAS*(DRODTD-FACT2)                    CBM  731
     1          -DSDT*RO1*CP1/DEL(I))                                 CBM  732
      TERM1=FACT1*DVB                                                 CBM  733
      B(I)=TERM2-A(I)+TERM1                                           CBM  734
      C(I)=-TERM1                                                     CBM  735
      D(I)=TA(I)*TERM2+(HGAS*DRODTD-HBAR*(RON(I)                      CBM  736
     1       -RO(I))/DTH-FACT2*HGAS-DSDT*RO1*H1/DEL(I))*DTH           CBM  737
   15 RO1=ROT(I+1)                                                    CBM  738
      PETE=0.0
      ZZZ=RHO(1)-RHOCI(I+1)
      IF (ZZZ.NE.0.0) PETE=RHO(1)/ZZZ
      PET = PETE*RHOCI(I+1)
      X1=PETE-PET/RO1                                                 CBM  739
      CP1=CPV(I+1)*X1+CPC(I+1)*(1.0-X1)                               CBM  740
      H1=HP(I+1)*X1+HC(I+1)*(1.0-X1)                                  CBM  741
      CP(I+1)=CPV(I+1)*X(I+1)+CPC(I+1)*(1.0-X(I+1))                   CBM  742
      TN=-RO1*HBAR+RO1*H1+1                                           CBM  743
      HBAR=PETE*HP(I+1)-PET/RHO(1)*HC(I+1)                            CBM  744
```

```
      T=-RO1*H1+RO1*HBAR                                                CBM  745
      CALL LOOK (2,TA(I+1),111,THG,0,0,0,HGAS,CPGAS,1)
      HGAS=HGAS+DELHG                                                   CBM  747
      GSEGR=GSEGR+HGAS*DMDG(I+1)                                        CBM  748
      SOEGR=SOEGR+HBAR*DMDG(I+1)                                        CBM  749
      IF(I.GT.0) GO TO 25
      EGO=GSMS*HGAS
      HW=HGAS                                                           CBM  752
      GO TO 30                                                          CBM  753
   25 TERM3=(-FACT2*CPGAS-DSDT*RO1*CP1/DEL(I))*DTH                      CBM  754
      C(I)=C(I)+TERM3                                                   CBM  755
      D(I)=D(I)+TA(I+1)*TERM3+(FACT2*HGAS+DSDT*RO1*H1/DEL(I))*DTH       CBM  756
      TB=TB-TN*DSDT*RR(I)                                               CBM  757
   30 CONTINUE                                                          CBM  758
      A(1)=DTH/DEL(1)                                                   CBM  759
      TT=TT+TB*DTH/AREA(1)*ASU                                          CBM  760
C     ---------- NOW THE LAST ABLATING NODE REQUIRES DIFFERENT TREATMENTCBM  761
      DRODTD=-DMDG(NL)/(RR(NL)*DEL(NL))                                 CBM  762
      FACT1=DTH/(DEL(NL)*RR(NL))                                        CBM  763
      A(NL)=-FACT1*DVB
      IF(LGAP(NL).NE.0)
     1DVB = RATG(NL ) + 4.0*TA(NBM)**3/EMISF(NL)
      IF(LGAP(NL).EQ.0) DVB = 2.0/(RAT(NL)+RAT(NBM))
      C(NL)=-FACT1*DVB                                                  CBM  766
      TERM2=RON(NL)*CP(NL)-(CPGAS*DRODTD+(DSDT/DEL(NL))*                CBM  767
     1         (RO (NL)*CPNL   -RO1*CP1))*DTH                           CBM  768
      B(NL) = TERM2 - A(NL)
      IF(LGAP(NL).EQ.0) B(NL ) = B(NL) - C(NL)
      IF(LGAP(NL).NE.0) B(NL ) = B(NL) + FACT1*(RATG(NL)
     1                          + 4.0*TA(NL)**3/EMISF(NL))
      D(NL)=TA(NL)*TERM2+DTH*(HGAS*DRODTD-HBAR*(RON(NL)-                CBM  770
     1        RO(NL))/DTH+DSDT*(RO (NL)*H(NL)-RO1*H1)/DEL(NL))          CBM  771
     2 + QGEN(NL)*DTH
      IF(LGAP(NL).NE.0) D(NL )=D(NL)+3.0*FACT1*(TA(NL)**4-TA(NBM)**4)
     1 /EMISF(NL)
      K = NL                                                            CBM  772
      GSM=GSM-DMDG(NL)                                                  CBM  773
      IF(NDBU.EQ.0) GO TO 7171
      FACT2=GSM/(DEL(NL)*RR(NL))
      TERM2=FACT2*CPGAS*DTH                                             CBM  776
      B(NL)=B(NL)+TERM2                                                 CBM  777
      D(NL)=D(NL)+TA(NL)*TERM2-FACT2*HGAS*DTH                           CBM  778
      CALL LOOK(2,TA(NBM),111,THG,0,0,0,HGAS,CPGAS,1)                   CBM  779
      HGAS=HGAS+DELHG                                                   CBM  780
      C(NL)=C(NL)-FACT2*CPGAS*DTH                                       CBM  781
      D(NL)=D(NL)-TA(NBM)*FACT2*CPGAS*DTH+FACT2*HGAS*DTH                CBM  782
 7171 CONTINUE                                                          CBM  783
C     ---------- NOW FOR DECOMPOSING BACK-UPS IF ANY                    CBM  784
      IF(NDBU.LE.0) GO TO 7250
      DO 720  L=1,NDBU
      LL=NFI(L)-1                                                       CBM  787
      LU=NLA(L)                                                         CBM  788
      DO 7241  I=LL,LU                                                  CBM  789
      IF(I-NFI(L).EQ.-1) GO TO 726
         GSM=GSM-DMDG(I)
      DVBS=DVB                                                          CBM  792
         K=K+1                                                          CBM  793
         DRODTD=-DMDG(I)/(RR(I)*DEL(I))                                 CBM  794
         FACT1=DTH/(DEL(I)*RR(I))                                       CBM  795
         FACT2=GSM/(DEL(I)*RR(I))                                       CBM  796
```

```
          A(K)=-FACT1*DVB                                                    CBM  797
          DVB=1.0/(0.5*(RAT(I)+RAT(I+1))+RC(I)/RR(I))                        CBM  798
          TERM2=RON(I)*CP(I)-DTH*(CPGAS*(DRODTD-FACT2))                      CBM  799
          TERM1=FACT1*DVB                                                    CBM  800
          B(K)=TERM2-A(K)+TERM1                                              CBM  801
          C(K)=-TERM1                                                        CBM  802
          D(K)=TA(I)*TERM2+(HGAS*DRODTD-HBAR*(RON(I)-RO(I))/DTH              CBM  803
        C    -FACT2*HGAS)*DTH                                                CBM  804
         IF(I-NLA(NDBU)) 726,727,727                                         CBM  805
  726    CP(I+1)=CPV(I+1)*X(I+1)+CPC(I+1)*(1.0-X(I+1))                       CBM  806
         HBARS=HBAR                                                          CBM  807
          HBAR=P(L)*HP(I+1)-PP(L)/RHOV(L)*HC(I+1)                            CBM  808
         CALL LOOK (2,TA(I+1), TT1,THG,0,0,0,HGAS,CPGAS,1)                   CBM  809
          HGAS=HGAS+DELHG                                                    CBM  810
         IF(I-NFI(L)+1) 7241,7241,727
  727    TERM3= (-FACT2*CPGAS)*DTH                                           CBM  812
          C(K)=C(K)+TERM3                                                    CBM  813
          D(K)=D(K)+TA(I+1)*TERM3+FACT2*HGAS*DTH                             CBM  814
 7241 CONTINUE                                                               CBM  822
  720 CONTINUE                                                               CBM  823
C     ---------- NOW FOR BACK UPS IF ANY                                     CBM  824
 7250 IF(NUMN.LT.NBM2) GO TO 60
      DO 50 I=NBM2,NUMN
      K=K+1                                                                  CBM  827
      FACT1=DTH/(DEL(I)*RR(I))                                               CBM  828
      D(K) = TA(I)*RO(I)*CP(I) + QGEN(I)*DTH
      IF(LGAP(I).EQ.0) GO TO 41
      L1 = I-1
      IF(I.EQ.NBM2) L1=NL
      IF(LGAP(L1 ).EQ.0) GO TO 42
      A(K) = -FACT1*(4.0*TA(L1 )**3/EMISF(L1 ) + RATG(L1 )   )
      C(K) = -FACT1*(4.0*TA(I+1)**3/EMISF(I)    + RATG(I)     )
      B(K) = RO(I)*CP(I) + FACT1*(RATG(I) + RATG(L1 ) +
     1        4.0*TA(I)**3*(1.0/EMISF(I) + 1.0/EMISF(L1 ) ) )
      D(K)=D(K)+3.0*FACT1*((TA(I)**4-TA(L1 )**4)/EMISF(L1 )
     1        +(TA(I)**4 - TA(I+1)**4)/EMISF(I)  )
      GO TO 43
   41 L1 = I-1
      IF(I.EQ.NBM2) L1=NL
      IF(LGAP(L1).EQ.0) GO TO 44
      A(K) = -FACT1*(RATG(L1 ) + 4.0*TA(L1 )**3/EMISF(L1 ))
      C(K) = -FACT1*2.0/(RAT(I) + RAT(I+1))
      B(K) = RO(I)*CP(I) - C(K) + FACT1*(RATG(L1 )
     1    + 4.0*TA(I)**3/EMISF(L1 )  )
      D(K) = D(K) + 3.0*FACT1*(TA(I)**4 - TA(L1 )**4)/EMISF(L1 )
      GO TO 43
   44 A(K) = -FACT1*DVB
      DVB = 2.0/(RAT(I) + RAT(I+1))
      C(K)=-FACT1*DVB                                                        CBM  831
      B(K)=RO(I)*CP(I)-C(K)-A(K)                                             CBM  832
      GO TO 50
   42 A(K) = -FACT1*DVB
      C(K) = -FACT1*(RATG(I) + 4.0*TA(I+1)**3/EMISF(I))
      B(K) = RO(I)*CP(I) - A(K) + FACT1*(RATG(I)+4.0*TA(I)**3/EMISF(I) )
      D(K) = D(K) + 3.0*FACT1*(TA(I)**4 - TA(I+1)**4)/EMISF(I)
   43 DVB = 2.0/(RAT(I)+RAT(I+1))
   50 CONTINUE
C
C     ---------- NOW IF THE LAST NODE WAS INSULATED WE MUST                  CBM  834
C                REPAIR LAST B AND C
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C
   60 IF(IBUG.NE.0) WRITE(6,5603) (A(I),B(I),C(I),D(I),RR(I),DEL(I),     BUG
     1   I=1,NUMN)                                                      BUG
      IF(IBUG.NE.0) WRITE(6,5603) (QGEN(I), I=1,NUMN)
      IF(HRES.NE.0.0) GO TO 80
      B(K)=B(K)+C(K)
      C(K)=0.                                                           CBM  837
C     ---------- NOW BEFORE GAUSS REDUCTION REWRITE LAST LINE OF MATRIX CBM  838
   80 D(K)=D(K)-C(K)*TRES                                               CBM  839
      L=K                                                               CBM  840
        DO 90 I=2,K                                                     CBM  841
        L=L-1                                                           CBM  842
        D(L)=D(L)-C(L)/B(L+1)*D(L+1)                                    CBM  843
   90   B(L)=B(L)-C(L)/B(L+1)*A(L+1)                                    CBM  844
      B(1)=B(1)/A(1)                                                    CBM  845
      D(1)=D(1)/A(1)                                                    CBM  846
      IF(IBUG.NE.0) WRITE(6,5603) (A(I),B(I),C(I),D(I),RR(I),DEL(I),    BUG
     1   I=1,NUMN)                                                      BUG
      PGPU=EGO-GSEGR                                                    CBM  847
      PGPUT=PGPUT+PGPU*DTH/AREA(1)*ASU                                  CBM  848
      DECOM=GSEGR-SOEGR                                                 CBM  849
      DECOMT=DECOMT+DECOM*DTH/AREA(1)*ASU                               CBM  850
      IF (ISR.NE.0) DSDT = DSXX
C                                                                       CBM  851
C     SURFACE BOUNDARY CONDITION PACKAGE                                CBM  852
C                                                                       CBM  853
      CHZ=CH                                                            CBM  854
      XP1=X(1)                                                          CBM  855
      ITL=10                                                            CBM  856
      ITS=1                                                             CBM  857
      SNET=(1.+SWELL)*SA-SWELL*CPE(1)                                   CBM  858
      IF(II-2) 2502,1420,2501                                           CBM  859
 1420 DSDTB=QRA/12000.0                                                 CBM  860
      TA(1)=HE                                                          CBM  861
      HE=0.                                                             CBM  862
      HW=0.0                                                            CBM  863
      BR=0.0                                                            CBM  864
      CND=DSDTB*((ROA(1)+ROB(1))*GAMA+ROC(1)*OMG)                       CBM  865
      RAD=0.                                                            CBM  866
      QRA=0.                                                            CBM  867
      QCHEM=0.                                                          CBM  868
      QCONV=0.                                                          CBM  869
      GO TO 1437                                                        CBM  870
 2501 TABC=90000.0                                                      CBM  871
      DSDTB=0.                                                          CBM  872
      ERFX=D(1)                                                         CBM  873
      QCHEM=0.                                                          CBM  874
      QCONV=0.                                                          CBM  875
      GO TO 2503                                                        CBM  876
 2502 IF(NR.LE.0) GO TO 1424
C     ---------- RADIUS CHANGE CORRECTION TO HEATING COEFFICIENT
      CH=CH/((1.+SNET/ABS(RSV))**REX)
      CHZ=CH                                                            CBM  879
 1424 BF (CND-CHFL)/(CH+1.0E-15)
C     ---------- FISSURE MODEL
      IF(NFIS.EQ.1) BF = BF + GS/(CH+1.0E-15)
      PHI=2.*BRP*BF                                                     CBM  885
C     ---------- BLOWING CORRECTION TO HEATING RATE
      IF (BRP.LT.0.0) GO TO 1421
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      IF(PHI.GT.0.01) GO TO 1423
      CH=CH*(1.-.5*PHI)
      GO TO 1426                                                    CBM  888
 1423 IF (PHI.LT.150.0) CH=CH/(EXP(PHI)-1.0)*PHI
      IF (PHI.GE.150.0) CH=0.05*CH
      GO TO 1426
C     ---------- PUTZ AND BARTLETTE CORRELATION
 1421 IF (BF.LT.0.00001) BF=0.00001
      IF (BF.GT.187.0) PHI=149.0
      IF (BF.LT.187.0) PHI=1.35*BF*EXP(0.14*(BF**1.333))
      IF (PHI.GT.0.01) GO TO 1422
      CH = CH*(1.0-0.5*PHI)
      GO TO 1426
 1422 IF (PHI.LT.150.0) CH=CH/(EXP(PHI)-1.0)*PHI
      IF (PHI.GE.150.0) CH=0.05*CH
 1426 IF (IBUG.NE.0)  WRITE(6,7043) ITER,TH,CH,BF,PHI
      IF(NFIS.EQ.2) GO TO 14261
      TEMP9 = AMAX1(TMG(1,1),TMG(NMGX,1))
      IF(TEMP9.NE.0.0) CH = AMAX1(CH,GS/TEMP9)
14261 CONTINUE                                                      CBM  892
      IF(IBUG.NE.0) WRITE(6,5602) RSV,PHI,AREA(1),TMG(1,1)          BUG
      ERFX=CH*HE+D(1)                                               CBM  893
      IBOT=+1
      IMG = 1
      IF(NGS.LE.1) GO TO 2511
C     ---------- INTERPOLATION FRACTION, VMR, USING GAS FLOW
      CALL LOOK (12,GS/(CH*CMH+1.0E-15),TMG,0,0,0,0,Y2,D2,0)
      IMG=IR(12)                                                    CBM  895
      VRM=VR                                                        CBM  896
C     ---------- INTERPOLATION FRACTION, VRP, USING LN PRESSURE
 2511 CALL LOOK(13,PRES,TPR,0,0,0,0,Y2,D2,0)                        CBM  899
      IPR=IR(13)                                                    CBM  900
C
C ----- (CCC COMMENT ON 12/87)
C     IHI(14),ILO(14) = HIGH AND LOW ENTRIES IN ABLATION PART OF EST
C                       AT PRESSURE TABLE NUMBER IPR
C                        NHI(IMG,IPR),NLO(IMG,IPR)
C
C     IHI(16),ILO(16) = HIGH AND LOW ENTRIES IN ABLATION PART OF EST
C                       AT PRESSURE TABLE NUMBER IPR+1
C                        NHI(IMG,IPR+1),NLO(IMG,IPR+1)
C
      ILO(16)=NLO(IMG,IPR+1)                                        CBM  901
      IHI(16)=NHI(IMG,IPR+1)                                        CBM  902
      ILO(14)=NLO(IMG,IPR)
      IHI(14)=NHI(IMG,IPR)                                          CBM  909
      VRP=VR                                                        CBM  905
C
      I3=ILO(16)                                                    CBM  906
      I1=ILO(14)                                                    CBM  912
      IF(NGS.LE.1) GO TO 2512
      ILO(17)=NLO(IMG+1,IPR+1)                                      CBM  903
      IHI(17)=NHI(IMG+1,IPR+1)                                      CBM  904
      ILO(15)=NLO(IMG+1,IPR)                                        CBM  910
      IHI(15)=NHI(IMG+1,IPR)                                        CBM  911
      I4=ILO(17)                                                    CBM  907
      I2=ILO(15)                                                    CBM  913
      IF(IHI(17).LE.I4) GO TO 420
      IF(IHI(15).LE.I2) GO TO 420
 2512 IF(IHI(14).LE.I1) GO TO 420
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      IF(IHI(16).LE.13) GO TO 420
C
C ----- COMPUTE NON-ABLATOR TEMPERATURE
      IF(JTBL.LT.0.OR.IOPTN.EQ.0) GO TO 2515
      IF(TABCN.LE.0.0) GO TO 2513
      TABC = TABCN
      GO TO 2503
C ----- SEARCH FOR TABC
 2513 IF(MITER.NE.1.AND.MOD(ITER,MITER).NE.1) GO TO 2503
      CALL FDTABC(TABC)
      IF(IMSG.GE.1) WRITE(6,2514)ITER,TABC
 2514 FORMAT(' ******** FDIABC SEARCH - ITER., NON-ABLAT. TEMP. = '
     1 ,I5,F12.5)
      GO TO 2503
C
 2515 TABC = TTS(I1,IMG,IPR)+VRP*(TTS(I3,IMG,IPR+1)-TTS(I1,IMG,IPR))
      IF(NGS.LE.1) GO TO 2503
      TABC = TABC+VRM*(TTS(I2,IMG+1,IPR)-TTS(I1,IMG,IPR))
     1 +VRP*(VR*(TTS(I4,IMG+1,IPR+1)-TTS(I3,IMG,IPR+1))
     2 -VRM*(TTS(I2,IMG+1,IPR)-TTS(I1,IMG,IPR)))
 2503 IF(IBUG.NE.0) WRITE(6,5601) I1,I2,I3,I4,IMG,IPR,NGS,NR,ITER
C
      IF(TSAVE.LE.TABC) GO TO 420
C
C     ----------  ABLATING SURFACE                                    CBM  924
C
      IF(IAB.GT.0) GO TO 423
      CMDL=TLMC(I1,IMG,IPR)-VRP*(TLMC(I1,IMG,IPR)-TLMC(I3,IMG,IPR+1))
      CMD=EXP(CMDL)*CH                                                CBM  927
      IAB=1                                                           CBM  928
  423 JD=0
C ----- BYPASS DIKI-TO-TABLES TRANSITION OF IOPTN = 0
      IF(IOPTN.LE.0) GO TO 509
      IF(FACTOR.EQ.-1.0.AND.TSAVE.GT.TABC) GO TO 505
      IF(MOD(ITER,MITER).NE.1) GO TO 508
C ----- SET TRANSITION TEMP. IF IOPTN '1' USED
  505 IF(FFLAG1.EQ.ITER) GO TO  508
      IF(IOPTN.EQ.1) XTEMP=TCRIT
C ----- MERGE2 CALLS XTEMP FROM TABLES BASED ON GIVEN BPRIME.
      IF(IOPTN.EQ.2) CALL MERGE2(XTEMP)
C ----- MERGE3 SEARCH FOR TEMP. WITH SMALLEST DIFFERENCE IN SLOPES
      IF(IOPTN.GE.3) CALL MERGE3(XTEMP)
        FFLAG1=ITER
  508 IF(TSAVE.GT.XTEMP) GO TO 510
C
  509 IF (JTBL.GE.0) GO TO 4260
C     ----------  INTERPOLATE LOG B PRIMES
  510 FACTOR=-1.0
      CALL LOOK(14,CMDL,TLMC(1,IMG,IPR),TTS(1,IMG,IPR),TCHEM(1,IMG,IPR),CBM  929
     1TBPF(1,IMG,IPR),0,Y2(1),Y2(4),3)                                CBM  930
      IRA=IR(14)                                                      CBM  931
      CALL LOOK(16,CMDL,TLMC(1,IMG,IPR+1),TTS(1,IMG,IPR+1),TCHEM(1,IMG,ICBM
     1PR+1),TBPF(1,IMG,IPR+1),0,Y2(13),Y2(16),3)                      CBM  937
      IRC=IR(16)                                                      CBM  938
      ITOP = 6
      IF(NGS.LE.1) GO TO 4233
      ITOP = 12
      CALL LOOK(15,CMDL,TLMC(1,IMG+1,IPR),TTS(1,IMG+1,IPR),TCHEM(1,IMG+1CBM  932
     1,IPR),TBPF(1,IMG+1,IPR),0,Y2(7),Y2(10),3)                       CBM  933
      IRB=IR(15)                                                      CBM  934
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      CALL LOOK(17,CMDL,TLMC(1,IMG+1,IPR+1),TTS(1,IMG+1,IPR+1),TCHEM(1,ICBM  939
     1MG+1,IPR+1),TBPF(1,IMG+1,IPR+1),0,Y2(19),Y2(22),3)                  CBM  940
      IRD=IR(17)                                                          CBM  941
 4233 IF(IBUG.NE.0) WRITE(6,5601) IAB,IRA,IRC,IRB,IRD,IMG,IPR,NGS         BUG
      IF(IBUG.NE.0) WRITE(6,5602) VRP,VRM,CMDL,(Y2(I),I=1,24)             BUG
C     --------- INTERPOLATE ON LOG PRESSURE
        DO 4232 I=1,ITOP
 4232   Y2(I)=Y2(I)+VRP*(Y2(I+12)-Y2(I))                                  CBM  943
      IF(NBPF.LE.1) GO TO 4237
      IF(VRP.LE.1.0) GO TO 4234
      Y2(3)=Y2(15)
      IF(NGS.LE.1) GO TO 4231
      Y2(9)=Y2(21)                                                        CBM  947
      GO TO 4237                                                          CBM  948
 4234 IF(VRP.GE.0.0) GO TO 4237
      Y2(3)=(Y2(3)-Y2(15)*VRP)/(1.-VRP)
      IF(NGS.LE.1) GO TO 4231
      Y2(9)=(Y2(9)-Y2(21)*VRP)/(1.-VRP)                                   CBM  951
 4237 IF(NGS.LE.1) GO TO 4231
      DO 426 I=1,6
  426 Y2(I)=Y2(I)+VRM*(Y2(I+6)-Y2(I))                                     CBM  954
 4231 IF(Y2(1).GT.0.0) GO TO 4261
      ITL=ITS
      GO TO 4356                                                          CBM  957
C
 4260 CONTINUE
C --- IF IBOT=+1, DIKI RETURNS Y2(4)=-1.0 ONLY
      CALL DIKI(PRES,CMDL,CH,Y2,TL,BPLH,IBOT,JTBL)
C --- FFLAG = ITERATION AT WHICH FACTOR IS FIRST COMPUTED (OR UPDATED)
C     IF(IMSG.EQ.2) WRITE(6,1510)ITER,MITER,FFLAG,FACTOR,IOPTN
C1510 FORMAT(' ******** ITER,MITER,FFLAG,FACTOR,IOPTN, = ',
C    1 ,/, 10X,3I5,F10.5,I5)
      IF(IOPTN.LE.0) GO TO 405
      IF(FACTOR.EQ.-1.0) FFLAG = ITER
      IF(IBOT.GT.0) GO TO 405
      IF(MITER.EQ.1.OR.FFLAG.EQ.ITER) GO TO 91
      IF(MOD(ITER,MITER).NE.1) GO TO 506
C --- COMPUTE FACTOR TO MERGE CURVES
   91 CALL MERGER(FACTOR,XTEMP)
C --- ADJUST BPRIME BY FACTOR
  506 CCC=EXP(CMDL)
      CMDL=ALOG(AMAX1(FACTOR*CCC,1.0E-5))
      CMDLP=EXP(CMDL)
      IF(MITER.EQ.1.OR.FFLAG.EQ.ITER) GO TO 92
      IF(MOD(ITER,MITER).NE.1) GO TO 405
   92 IF(IMSG.GE.1) WRITE(6,100)TH,ITER,XTEMP,TS,FACTOR,CCC,CMDLP
  100 FORMAT(' ***1*** MERGER -  TIME,  ITER,   XTEMP,     TWALL,     ',
     1' FACTOR,    BP,   BP*FACTOR = ',/,17X,F9.4,I5,2F12.5,3F9.5)
C
  405 JD=1
      IF (Y2(4).LE.0.0) GO TO 4359
C --- SECOND CALL ON DIKI IF Y2(4).LE.0
      GO TO 4261
 4359 CMDL=BPLH
      IBOT=-1
      Y2(1)=TS
      CALL DIKI(PRES,CMDL,CH,Y2,TL,BPLH,IBOT,JTBL)
C --- USE FACTOR FROM FIRST CALL TO DIKI TO MERGE CURVES
      IF(IOPTN.LE.0) GO TO 4261
C --- ADJUST BPRIME BY FACTOR
```

```
      CCC=EXP(CMDL)
      CMDL=ALOG(AMAX1(FACTOR*CCC,1.0E-5))
      CMDLP=EXP(CMDL)
      IF(MITER.EQ.1.OR.FFLAG.EQ.ITER) GO TO 93
      IF(MOD(ITER,MITER).NE.1) GO TO 4261
   93 IF(IMSG.GE.1) WRITE(6,99)TH,ITER,XTEMP,TS,FACTOR,CCC,CMDLP
   99 FORMAT(' ***2*** MERGER - TIME,  ITER,   XTEMP,     TWALL,     ',
     1' FACTOR,     BP,   BP*FACTOR = ',/,17X,F9.4,I5,2F12.5,3F9.5)
 4261 CONTINUE                                                          CBM  958
C ----- LOOK UP EMMISSIVITY OF SURFACE MATERIAL
      CALL LOOK(4,Y2(1),TT2(1,2),TEP(1,2),0,0,0,EMIV,DMIV,1)            CBM  959
      IF(MATL(1).EQ.2) GO TO 427
      CALL LOOK(3,Y2(1),TT2(1,1),TEP(1,1),0,0,0,Y3,D3,1)
      EMIV=EMIV+XP1*(Y3(1)-EMIV)                                        CBM 962
      DMIV =DMIV+XP1*(D3(1)-DMIV)                                       CBM 963
  427 TSSQ=Y2(1)*Y2(1)                                                  CBM  964
      TS=Y2(1)                                                          CBM  965
C
C ----- COMPUTE DEPARTURE FROM ZERO OF SURFACE ENERGY BALANCE
C     RAD = RADIATION AWAY FROM SURFACE
C     QRA = INCIDENT RADIATION
C     ERR = DEPARTURE FROM ZERO OF SURFACE ENERGY BALANCE
C     DERR = RATE OF ERR PER LN(BPRIME) FOR ABLATING SURFACE OR
C            RATE OF ERR PER TWALL FOR NON-ABLATING SURFACE.
C     ERRC = CORRECTION TO LN(BPRIME)
C
C ----- BLOWING EFFECT ON RADIATIVE HEAT TRANSFER
C ---- DD1 = DENSITY AT ALTITUDE AFTFS
C ---- BLOW = PERCENT BLOWING
C ---- BLOFAC = BLOW FACTOR ON RADIATION H.T., QRA
C
      IF(IBLOPT.LE.0) GO TO 5000
      CALL ATM(AFTFS,DUMP,DUMT,DUMW,DUMA,DD1)
      BLOW=CMD/(VELFS*DD1)*100.0
      IF(IBLOPT.EQ.1) GO TO 5100
C ------ USING CARBON ABLATION SPECIES
        IF(BLOW.GT.20.0)                          BLOFAC=0.60
        IF(BLOW.GT.10.0.AND.BLOW.LE.20.0) BLOFAC=0.70-0.005*BLOW
        IF(BLOW.GT. 5.0.AND.BLOW.LE.10.0) BLOFAC=0.85-0.020*BLOW
        IF(BLOW.GE. 0.0.AND.BLOW.LE. 5.0) BLOFAC=1.00-0.050*BLOW
        GO TO 5150
C ------ USING AIR ABLATION SPECIES
 5100   IF(BLOW.GT.40.0)                          BLOFAC=0.83
        IF(BLOW.GT.20.0.AND.BLOW.LE.40.0) BLOFAC=0.91-0.002*BLOW
        IF(BLOW.GT.10.0.AND.BLOW.LE.20.0) BLOFAC=0.93-0.003*BLOW
        IF(BLOW.GE. 0.0.AND.BLOW.LE.10.0) BLOFAC=1.00-0.010*BLOW
C -----
 5150 IF(IBLOPT.GE.1.AND.IMSG.GE.3)
     1   WRITE(6,5200)ITER,CMD,VELFS,DD1,BLOW,BLOFAC
 5200 FORMAT(' ******* ITER,CMD,VELFS,DENS,BLOW,BLOFAC = ',
     1 /,' ******* ',I5,5E14.5)
 5000 CONTINUE
C ------- QRA CHANGED TO QRA*BLOFAC BELOW BY CCC 1/88
      RAD=SIG*EMIV*TSSQ*TSSQ*VF                                         CBM  966
      ERR=CH*Y2(2)+EMIV*QRA*BLOFAC-RAD-B(1)*TS+ERFX
      DERR=CH*Y2(5)+((QRA*BLOFAC-RAD/EMIV)*DMIV-4./TS*RAD-B(1))*Y2(4)   CBM  968
      ERRC=ERR/DERR                                                     CBM  969
      VITER(ITS)=CMDL                                                   CBM  970
      EITER(ITS)=ERR                                                    CBM  971
      IF(ERRC.EQ.0.0) GO TO 4355
```

```
      IF(ABS(ERRC).LT.1.0E-6) ERRC = ERRC/ABS(ERRC)*1.0E-6
 4355 IF (IBOT.LT.0) GO TO 4357
      CMDL = CMDL - ERRC
      GO TO 4358
 4357 TS = TS-ERRC
      Y2(1) = TS
 4358 IF(IBUG.NE.0) WRITE(6,5602) (Y2(I),I=1,6)                          BUG
      IF (JD.EQ.1) GO TO 4367
      CMMI=-1.E+30                                                       CBM  973
      CMMA=+1.E+30                                                       CBM  974
      IF(ILO(14).GE.IRA) GO TO 4363
      IF(ILO(16).GE.IRC) GO TO 4363
      IF(NGS.LE.1) GO TO 4270
      IF(ILO(17).GE.IRD) GO TO 4363
      IF(ILO(15).GE.IRB) GO TO 4363
      CMMI = AMAX1(TLMC(IRD,IMG+1,IPR+1)+TLMC(IRD-1,IMG+1,IPR+1),
     1             TLMC(IRB,IMG+1,IPR) + TLMC(IRB-1,IMG+1,IPR))
 4270 CMMI = AMAX1(TLMC(IRA,IMG,IPR)+TLMC(IRA-1,IMG,IPR),CMMI,
     1             TLMC(IRC,IMG,IPR+1)+TLMC(IRC-1,IMG,IPR+1))/2.0
      CMDL=AMAX1(CMDL,CMMI)                                              CBM  985
 4363 IF(IHI(14).LE.IRA+1) GO TO 4366
      IF(IHI(16).LE.IRC+1) GO TO 4366
      IF(NGS.LE.1) GO TO 4275
      IF(IHI(17).LE.IRD+1) GO TO 4366
      IF(IHI(15).LE.IRB+1) GO TO 4366
      CMMA = AMIN1(TLMC(IRD+1,IMG+1,IPR+1) + TLMC(IRD+2,IMG+1,IPR+1),
     1             TLMC(IRB+1,IMG+1,IPR) + TLMC(IRB+2,IMG+1,IPR))
 4275 CMMA = AMIN1(CMMA,TLMC(IRC+2,IMG,IPR+1)+TLMC(IRC+1,IMG,IPR+1),
     1             TLMC(IRA+1,IMG,IPR)+TLMC(IRA+2,IMG,IPR))/2.0
      CMDL=AMIN1(CMDL,CMMA)                                              CBM  996
      IF(ITS-ITL-1) 4366,4351,4352                                       CBM  997
 4351 ERRS=ERR                                                           CBM  998
      CMDL=CMMA                                                          CBM  999
      GO TO 4367                                                         CBM 1000
 4352 IF(ERR*ERRS) 4354,4367,4353                                        CBM 1001
 4353 CMDL=CMMA                                                          CBM 1002
      GO TO 4367                                                         CBM 1003
 4354 ITL=55                                                             CBM 1004
      IF(ERRC.EQ.0.0) CMDL = CMMI
      GO TO 4367                                                         CBM 1007
 4366 IF(ITS.NE.ITL) GO TO 4367
 4356 CMDL = AMIN1(TLMC(I1,IMG,IPR),TLMC(I3,IMG,IPR+1))
      IF(NGS.LE.1) GO TO 4367
      CMDL = AMIN1(CMDL,TLMC(I2,IMG+1,IPR),TLMC(I4,IMG+1,IPR+1))
 4367 IF (CMDL.GT.10.0) CMDL=10.0
      CMD=EXP(CMDL)*CH*CMH                                               CBM 1013
      IF(IBUG.NE.0) WRITE(6,5602) TH,DTH,VRM,ERFX,EMIV,DMIV,RAD,B(1),    BUG
     1 CH,PHI,D(1),HE,XP1,QRA,CMDL,CMMA,ERR,DERR,ERRC                    BUG
      IF (ITS.EQ.31) TOLER = 2.0*TOLER
      IF (ITS.LE.30)  GO TO 415
      IF (IBOT.LT.0)  GO TO 415
      DUM=EITER(ITS)-EITER(ITS-1)
C ----- IF SUCCESSIVE SURF. BALANCE ERRORS ARE SAME
      IF (DUM.EQ.0.0) GO TO 4376
      CMDL = VITER(ITS-1) - EITER(ITS-1)*(VITER(ITS)-VITER(ITS-1))
     1  /DUM
  415 IF(ITS.EQ.40) TOLER = 2.0*TOLER
      IF (ITS.EQ.50) GO TO 4376
      IF (ITS.LT.49) GO TO 4375
      XMIN = 1.0E+6
```

```
      DO 4374 I5 = 1,49
      IF(ABS(EITER(I5)).GT.XMIN) GO TO 4374
      CMDL = VITER(I5)
      XMIN = ABS(EITER(I5))
 4374 CONTINUE
 4375 ITS = ITS+1
      IF(ABS(ERR)-TOLER) 4372,4372,423
 4376 WRITE(6,5604) TH,ERR
 5604 FORMAT(37H NO CONV IN SURF BAL, TIME & ERR ARE   ,2F14.5 )
      GO TO 4372
C
C     ----------  NON-ABLATING SURFACE                                    CBM 1017
C
  420 TS=TSAVE                                                           CBM 1018
C ----- FLAG TO INDICATE NEED FOR MERGER SUBR WHEN
C       GOING FROM NON-ABLATOR TO ABLATOR USING DIKI
      FACTOR=-1.0
      BLOW=0.0
      BLOFAC=1.0
C
      IAB=0                                                              CBM 1019
      CMD=0.0                                                            CBM 1020
  430 IF(II.EQ.3) GO TO 433
      ILO(18)=1
      IHI(18)=KHI(IMG,IPR)                                               CBM 1023
      ILO(20)=1
      IHI(20)=KHI(IMG,IPR+1)                                             CBM 1032
      CALL LOOK (18,TS,TTS(1,IMG,IPR),TCHEM(1,IMG,IPR),0,0,0,Y2(1),Y2(2)CBM 1026
     1,1)                                                                CBM 1027
      CALL LOOK (20,TS,TTS(1,IMG,IPR+1),TCHEM(1,IMG,IPR+1),0,0,0,Y2(5), CBM 1035
     1Y2(6),1)                                                           CBM 1036
      IF(NGS.LE.1) GO TO 4322
      ILO(19)=1                                                          CBM 1024
      IHI(19)=KHI(IMG+1,IPR)                                             CBM 1025
      ILO(21)=1                                                          CBM 1033
      IHI(21)=KHI(IMG+1,IPR+1)                                           CBM 1034
      CALL LOOK (19,TS,TTS(1,IMG+1,IPR),TCHEM(1,IMG+1,IPR),0,0,0,Y2(3), CBM 1028
     1Y2(4),1)                                                           CBM 1029
      CALL LOOK (21,TS,TTS(1,IMG+1,IPR+1),TCHEM(1,IMG+1,IPR+1),0,0,0,   CBM 1037
     1Y2(7),Y2(8),1)                                                     CBM 1038
      DO 4321 I =1,2
 4321 Y2(I)=Y2(I)+VRM*(Y2(I+2)-Y2(I))
      DO 4423 I=5,6
 4423 Y2(I) = Y2(I) +VRM*(Y2(I+2)-Y2(I))
 4322 IF(IBUG.NE.0) WRITE(6,5601) IAB,IMG,IPR                            BUG
      IF(IBUG.NE.0) WRITE(6,5602) (Y2(I),I=1,8),TS,VRM,VRP               BUG
      DO 4323 I=1,2
 4323 Y2(I)=Y2(I)+VRP*(Y2(I+4)-Y2(I))
C ----- Y2(1) = -HW SINCE OLD Y2(1)=TCHEM=-(1+B')*HW+B'C*HC=-HW
      IF(IMSG.GE.3) WRITE(6,4330)ITER,PRES,TS,Y2(1)
 4330 FORMAT(' ******* ITER,PRES,TS,Y2(1) = ',I5,3E15.5)
C
      IF(IBUG.NE.0) WRITE(6,5602) (Y2(I),I=1,2)                          BUG
  433 CALL LOOK (4,TS,TT2(1,2),TEP(1,2),0,0,0,EMIV,DMIV,1)               CBM 1043
      IF(MATL(1).EQ.2) GO TO 442
      CALL LOOK (3,TS,TT2(1,1),TEP(1,1),0,0,0,Y3,D3,1)                   C
      EMIV=EMIV+XP1*(Y3(1)-EMIV)                                         CBM1046
      DMIV =DMIV+XP1*(D3(1)-DMIV)
  442 TSSQ=TS*TS                                                         CBM 1048
      IF(II.NE.3) GO TO 4422
```

```
      IF(EMIV.EQ.0.0) EMIV=1.0
 4422 RAD=SIG*EMIV*TSSQ*TSSQ*VF                                          CBM 1052
      ERR=CH*Y2(1)+EMIV*QRA-RAD-B(1)*TS+ERFX
      DERR=CH*Y2(2)+((QRA-RAD/EMIV)*DMIV-4./TS*RAD-B(1))                 CBM 1054
      ERRC=ERR/DERR                                                      CBM 1055
      VITER(ITS)=TS                                                      CBM 1056
      EITER(ITS)=ERR                                                     CBM 1057
      TS=TS-ERRC                                                         CBM 1058
      IF(II.GE.3) GO TO 4507
      TSMI=-1.E+30
      TSMA=+1.E+30                                                       CBM 1061
      IRA=IR(18)                                                         CBM 1062
      IRB=IR(19)                                                         CBM 1063
      IRC=IR(20)                                                         CBM 1064
      IRD=IR(21)                                                         CBM 1065
      IF(ILO(18).GE.IRA) GO TO 4501
      IF(ILO(20).GE.IRC) GO TO 4501
      IF(NGS.LE.1) GO TO 4503
      IF(ILO(21).GE.IRD) GO TO 4501
      IF(ILO(19).GE.IRB) GO TO 4501
      TSMI = AMAX1(TTS(IRD,IMG+1,IPR+1)+TTS(IRD-1,IMG+1,IPR+1),
     1             TTS(IRB,IMG+1,IPR) + TTS(IRB-1,IMG+1,IPR) )
 4503 TSMI = AMAX1(TSMI,TTS(IRA,IMG,IPR) + TTS(IRA-1,IMG,IPR),
     1             TTS(IRC,IMG,IPR+1)+TTS(IRC-1,IMG,IPR+1) )/2.0
      TS=AMAX1(TS,TSMI)                                                  CBM 1075
 4501 IF(IHI(18).LE.IRA+1) GO TO 4507
      IF(IHI(20).LE.IRC+1) GO TO 4507
      IF (NGS.LE.1)GO TO 4510
      IF(IHI(21).LE.IRD+1) GO TO 4507
      IF(IHI(19).LE.IRB+1) GO TO 4507
      TSMA = AMIN1(TTS(IRD+1,IMG+1,IPR+1)+TTS(IRD+2,IMG+1,IPR+1),
     1             TTS(IRB+1,IMG+1,IPR) + TTS(IRB+2,IMG+1,IPR))
 4510 TSMA = AMIN1(TSMA,TTS(IRA+1,IMG,IPR)+TTS(IRA+2,IMG,IPR),
     1             TTS(IRC+1,IMG,IPR+1)+TTS(IRC+2,IMG,IPR+1) )/2.0
      TS=AMIN1(TS,TSMA)                                                  CBM 1085
 4507 CONTINUE                                                           CBM 1086
      IF (IBUG.EQ.0) GO TO 104
                     WRITE(6,5601) IRA,IRB,IRC,IRD,IAB
                     WRITE(6,5602) TSMI,TSMA,TS,ERRC,DERR,ERR,
     1 VITER(ITS)                                                        BUG
                     WRITE(6,5602) TH,DTH,VRM,ERFX,EMIV,DMIV,RAD,B(1),   BUG
     1 CH,PHI,D(1),HE,XP1,QRA,CMDL                                       BUG
  104 IF(ITS.GT.50) GO TO 998
      ITS = ITS +1
      IF(ABS(ERR).GT.1.0) GO TO 430
C
C     ----------  POST ITERATION                                         CBM 1096
C
      IF(II.GT.2) GO TO 1437
      Y2(2) = Y2(1)
 4372 QCHEM=Y2(2)                                                        CBM 1099
C     IF (ITS.LT.30) GO TO 1438
C     WRITE(6,583) TOLER,ERR,TH
      IF(ISEN(1).NE.0) GO TO 4373
      QCONV = 0.0
      GO TO 1439
 4373 CALL OGLE(1,TS,QCONV,ISEN(IPR),ITSEN(1,IPR),THSEN(1,IPR),TCPSEN(1,CBM 1103
     1IPR))                                                              CBM 1104
      CALL OGLE(1,TS,QQ    ,ISEN(IPR+1),ITSEN(1,IPR+1),THSEN(1,IPR+1),TCPCBM 1106
     1SEN(1,IPR+1))                                                      CBM 1107
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      QCONV=QCONV+VRP*(QQ-QCONV)                                        CBM 1108
 1439 QCHEM=(QCHEM+QCONV)*CH
      HW=QCONV                                                          CBM 1110
      QCONV=CH*(HE-QCONV)                                               CBM 1111
      DSDTB=CMD/RHO(2)                                                  CBM 1112
C     ---------- EROSION LUNDELL & DICKEY DATA BASED ON JANAF SPECIES
      CMDM = 0.0
      DSDTM = 0.0
      IF(IEROS.EQ.0) GO TO 441
      IF(TS.LT.7245.0.AND.TS.GT.4600.0)
     1 CMDM = CMD*(564.59/(7521.0-TS)-0.15523)
      IF(TS.GT.7245.0) CMDM = 1.89*CMD
      DSDTM = CMDM/RHO(2)
  441 DSDTT = DSDTB + DSDTM
      IF(NBPF.LE.0) GO TO 1437
      IF(IAB.GT.0) CMFL = EXP(Y2(3))*CH*CMH
 1437 RO(1)=RON(1)                                                      CBM 1116
      BR=CH/(CHZ+1.0E-15)
      QRP=EMIV*QRA*BLOFAC                                               CBM 1118
      QCOND=-D(1)+B(1)*TA(1)                                            CBM 1119
      TEMP = DTH*ASU/AREA(1)
C     ---------- TIME INTEGRATED VALUES
      QCONVT = QCONVT + QCONV*TEMP
      QCHEMT = QCHEMT + QCHEM*TEMP
      QCONDT = QCONDT + QCOND*TEMP
      QRPT   = QRPT   + QRP*TEMP
      RADT   = RADT   + RAD*TEMP
      SUMQE = SUMQE + DTH*(QCONV+QRP-RAD+QCHEM-QCOND)
C     ---------- RECOMPUTE TOLERANCE
      TOLER =AMAX1(0.25,AMIN1(1.0,ABS(0.01*QCONV)))
C                                                                       CBM 1125
      DEDT=RON(1)*CP(1)*(TS-TSAVE)*DEL(1)/DTH                           CBM 1126
      DTDT(1) = (TS-TSAVE)/DTH
        DO 95 I=2,NL                                                    CBM 1127
        RO(I) = RON(I)                                                  CBM 1128
        TEMP =(D(I  )-A(I  )*TA(I-1))/B(I  )                            CBM 1129
        DEDT=DEDT+RON(I)*CP(I)*(TEMP-TA(I))*DEL(I)*RR(I)/DTH            CBM 1130
        DTDT(I) = (TEMP-TA(I))/DTH
   95   TA(I)=TEMP                                                      CBM 1131
      IF(NUMN.LT.NBM) GO TO 97
      K = NL
      TA(NBM-1) = TA(NL)                                                CBM 1134
        DO 98 I = NBM,NUMN                                              CBM 1135
        K = K+1                                                         CBM 1136
   98   TA(I) = (D(K)-A(K)*TA(I-1))/B(K)                                CBM 1137
   97 DEDTT=DEDTT+DEDT*DTH/AREA(1)*ASU                                  CBM 1138
      IF(IBUG.NE.0) WRITE(6,5602) (TA(I),I=1,NUMN)                      BUG
      IF(NDBU.EQ.0) GO TO 756
      LL = NFI(1)
      LU=NLA(NDBU)                                                      CBM 1141
        DO 757 I=LL,LU                                                  CBM 1142
  757   RO(I)=RON(I)                                                    CBM 1143
C                                                                       CBM 1146
C     SHRINK (AND DROP) OF LAST ABLATING NODE                           CBM 1147
C                                                                       CBM 1148
  756 IF(DEL(NL).GT.DELM) GO TO 150
      DRLP=DEL(NL)*RO(NL)*RR(NL)
      DRLCP=DRLP*CP(NL)                                                 CBM 1152
      NL=NL-1                                                           CBM 1153
      LGAP(NL) =LGAP(NL+1)
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      GAP(NL) = GAP(NL+1)
      RC(NL)=RC(NL+1)                                                    CBM 1154
      DRL=DEL(NL)*RO(NL)*RR(NL)                                          CBM 1155
      DRLC=DRL*CP(NL)                                                    CBM 1156
      HAPHB=DRL*H(NL)+DRLP*H(NL+1)                                       CBM 1157
      TOP1=DRL+DRLP                                                      CBM 1158
      TOP2=DRLC+DRLCP                                                    CBM 1159
      TOP3=DRLC*TA(NL) +DRLCP*TA(NL+1)                                   CBM 1160
      VOL=DEL(NL)*RR(NL)+DEL(NL+1)*RR(NL+1)                              CBM 1161
      DEL(NL)=DEL(NL)+DEL(NL+1)                                          CBM 1162
      RA(NL)=RA(NL)+6.*DEL(NL+1)                                         CBM 1163
      RO(NL)=TOP1/VOL                                                    CBM 1164
      CP(NL)=TOP2/TOP1                                                   CBM 1165
      TA(NL)=TOP3/TOP2                                                   CBM 1166
      H(NL)=HAPHB/TOP1                                                   CBM 1167
      DELR=DEL(NL+1)*RR(NL+1)/VOL                                        CBM 1168
      CZ=1.0-DELR                                                        CBM 1169
      DZ=0.0                                                             CBM 1170
      GZ=CZ                                                              CBM 1171
      NZ=JF*NL-JFH                                                       CBM 1172
      N=NZ-JF+1                                                          CBM 1173
      K=N                                                                CBM 1174
      FZ=DELR                                                            CBM 1175
      EZ=GZ                                                              CBM 1176
      GO TO 179                                                          CBM 1177
  172 DZ=DZ+1.0                                                          CBM 1178
  173 FZ=DZ-CZ                                                           CBM 1179
      IF(K.EQ.NZ) GZ=DELR
      K=K+1
      CZ=CZ+GZ                                                           CBM 1183
      EZ=CZ-DZ
      IF(EZ.LT.0.0) GO TO 178
      ROA(N)=ROA(N)+FZ*ROA(K)
      ROB(N)=ROB(N)+FZ*ROB(K)                                            CBM 1187
      ROC(N)=ROC(N)+FZ*ROC(K)                                            CBM 1188
      IF(N.EQ.NZ) GO TO 150
      N=N+1
  179 ROA(N)=ROA(K)*EZ                                                   CBM 1191
      ROB(N)=ROB(K)*EZ                                                   CBM 1192
      ROC(N)=ROC(K)*EZ                                                   CBM 1193
      GO TO 172                                                          CBM 1194
  178 ROA(N)=ROA(N)+ROA(K)*GZ                                            CBM 1195
      ROB(N)=ROB(N)+ROB(K)*GZ                                            CBM 1196
      ROC(N)=ROC(N)+ROC(K)*GZ                                            CBM 1197
      GO TO 173                                                          CBM 1198
C                                                                        CBM 1199
  150 GO TO 410
  998 WRITE (KOUT,529)                                                   CBM 1090
      WRITE(KOUT,582)(VITER(I),EITER(I),I=1,51)                          CBM 1091
      WRITE(KOUT,582) TH,DTH,VRM,ERFX,TABC,EMIV,DMIV,RAD,B(1),CH,PHI,    CBM 1092
     1 D(1),HE,XP1,QRA,Y2(1),Y2(2),Y2(3),Y2(4)                           CBM 1093
      TH=THFIN                                                           CBM 1094
      GO TO 3000                                                         CBM 1095
    1 RETURN
      END                                                                CBM 1202
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DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(FDTABC)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/13/88 013 14:11:54

      SUBROUTINE FDTABC(TABC)
C                                                                      CBM    2
C SUBROUTINE TO COMPUTE THE TEMPERATURE FOR THE MATERIAL TO ABLATE     CBM    3
C USING THE HUNTER FORMULATION REWRITTEN TO GIVE A BPRIME AS A         CBM    4
C FUNCTION OF TEMPERATURE.
C
C INPUT: PRES, RUCH  -  OUTPUT:TABC
C
      COMMON/OTPT/CPE(6),EMO(201),DEP(20,10),CNC(101),CN(101),Y1(4),
     1 CNO(101),TO(20),RO(101),NISO(20),BR,CH,GS,SA,TB,TT,ASU,CMD,CMT,
     2 ITS,QRP,RAD,RAT(101),RSU,CMDM,CMMT,DCDT,DEDT,DIDT,DPDT,ITER,KSCT,
     3 PGPU,PRES,QRPT,RADT,SNET,DECOM,DEDTT,DSDTB,PGPUT,QCHEM,QCOND,
     4 QCONV,QLOSS,SDNET,       SUMQE,THPRT,TSAVE,VELFS,DECOMT,
     5 PRSATM,QCHEMT,QCONDT,QCONVT,QLOSST,KK,RR(101),DMDG(101),
     6 RON(101),ROT(101),DNCP(6),DROT(6),D1(4),FA,FB,FC,DTH,DTHC,DSI,
     7 DTA,GSM,COLD,GSMS,GSMT,GSM2T,DSDT,POLD,DUM,AFTFS,DSDTT,
     8 TEMP,BF,LL,LU,HE,HW
      COMMON/OPTION/TCRIT,BPCRIT,TABCN,IOPTN,IMSG,MITER
      COMMON/DIKIBK/E1,K01,E2,K02,MWC,MWO,CON02
      DIMENSION TWL(50)
      REAL K1,K2,K01,K02,MWC,MWO
C ----- R IN ATM-CM**3/GM/K
C ----- PRES IN LN(ATM)
C ----- CH (RUCH) IN LBM/FT**2/S
C ----- GSTAR IN G/CM**2/S
C ----- TW IN K
C ----- E1 IN K
C ----- K01 IN CM/S
      BP=0.00001
      R = 2.83317
      PW=EXP(PRES)
      GSTAR=0.489*CH
      BE=MWC/MWO*CON02
      TERM = K01*PW/R/GSTAR*(ALOG(1.0+BE)/ALOG(1.0+BP)-1.0)
      TW=2000.0/1.8
      TOLER=0.1
C ----- ITERATE TO SOLVE FOR TW
C
      ICOUNT=0
   50 ICOUNT=ICOUNT+1
      TWL(ICOUNT)=TW
      TWLAST=TW
      TW = E1/ALOG(TERM/TW)
      TABC = TW*1.8
      IF(IMSG.GE.2) WRITE(6,100)ICOUNT,TABC
  100 FORMAT(' **FDT** FBTABC SUB-ITERATION NO. ',I3,
     1 ',    TABC = ',F12.5)
      IF(ICOUNT.LT.15) GO TO 200
        WRITE(6,150)(TWL(I),I=1,ICOUNT)
  150   FORMAT(' **FDT** WARNING: FDTABC MAX. ITERATIONS EXCEEDED'
     1   ,'*****'  ,/,15E12.5)
        RETURN
  200 IF(ABS(TW-TWLAST).GT.TOLER) GO TO 50
      RETURN
      END                                                              CBM 1202
```

```
DSNAME = 'BBE.CCC1.SOURCE.CMA5.PDS(INPOUT4)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/26/88 G26  15:31:53

      SUBROUTINE INPOUT
C
C     CHANGES TO PROGRAM:
C     (1/16/87) SIZE OF TTH,THE,TQR,TCM,TBRP,TALT,TVEL,TPI
C               EXPANDED TO 120 ELEMENT ARRAYS
C     (1/19/87) SIZE OF TTSEN,THSEN,TCPSEN,TLMC,TTS,TCHEM,TBPF,
C               TZSEN,TCZSEN,TSURF,TSEN,
C               TPR,NMG,TMG,NLO,NHI,KHI,ISEN,
C               EXPANDED TO ACCOMMODATE 20 EST TABLES WITH 30
C               ENTRIES EACH
C
C     (1/29/87) ALL OTHER SUBSCRIPTED VARIABLE DIMENSIONS DOUBLED
C               AS RECOMMENDED BY L.L. PERINI.
C
      COMMON KOUT,IEX,DEN,VR                                          CBM     5
      COMMON IHI(76),ILO(76),IR(76),TT2(60,20),TCP(60,20),TKP(60,20),THZCBM     6
     1(60,20),TEP(60,20),TTH(120),THE(120),TQR(120),TCM(120),TT1(60)    INPOU  4
     2,TMG(60),DH12(4),RECORD(108),SO(40),RHO(20),TEPBF(60,20)
      COMMON MATL(101),DEL(101),TA(101),H(101),RC(101),RA(101),
     1AREA(101),EMA(101),RAV(101),LGAP(101),QGEN(101),GAP(101)
      COMMON ROA(1000),ROB(1000),ROC(1000)                            CBM    12
      COMMON TPR(20),NMG(20),
     C                    TMG(5,20),NLO(5,20),NHI(5,20),KHI(5,20),
     1 TTSEN(30,20),THSEN(30,20),TCPSEN(30,20),TLMC(30,5,20),ISEN(20),
     2 TPI(120),  TTS(30,5,20),TCHEM(30,5,20),VFZ,CMH,TBPF(30,5,20),
     3 NPR,NGS
      COMMON LCT,NPG,II,NBM,NUMN,NL,DELHG,DELM,RFT,RHORA,RHORB,RHORC,TRACBM    18
     1CA,TRACB,TRACC,RHOOA,RHOOB,RHOOC,EA,EB,EC,BA,BB,BC,PSIA,PSIB,PSIC,CBM    19
     2TRACM,PET,PETE,RSV,ETA,DTPR3,DTPR2,DTPRT,TPR3,TPR2,THZRO,THFIN,WT,CBM    20
     3TMWT,GAMA,OMG,NO,FJHH,FJFS,JF,JHP,JFH,INPUT,     DTHIN,BRP,HCONV,CBM    21
     4EPSW,TRES,INCH,DTHB,NN,NI,NOI,CHCRI,PYCRI,TBRP(120),NR,
     5 TX(30,6),F1(30,6),F2(30,6),NCON,NBPF,NFIS,BREX,SWELL
      COMMON BBB(10,6),EE(10,6),FF(10,6),PSI(10,6),RHOO(10,6),
     XRHOR(10,6),
     1ROCOM(50,3),DHC(10),DHV(10),RHOC(10),RHOV(10),P(10),PP(10),
     XTREF(10),
     2GA(10),OMGA(10),NFI(10),NLA(10),115(60,20),TENT(60,20),
     XTKBU(60,20),
     3TCBU(30,10),X(101),NDBU,NBM2,TRAC(10,6),NBUFT(10),KNST,IBUG,TBUG,
     4 TALT(120),TVEL(120),RRGAP(101),AGAP(101),ICOND,IEROS,ISR,
     5 NGC1,NGC2,NGC3,NGC4,ICON1(101),ICON2(101),ICON3(101),ICON4(101),
     6 COND1(101),COND2(101),COND3(101),COND4(101),
     7 THCONV(101),TEPSW(101),TTRES(101),TQ(101),TEPSD(101),IBF,TL,THD,
     8 JTBL,IORD,RHOC1(201),DTDT(201),RA1,RA2,RA3
      COMMON/OPTION/TCRIT,BPCRIT,TABCN,IOPTN,IMSG,MITER,IBLOPT
      DIMENSION TZSEN(30,20),TCZSEN(30,20),TSURF(30),TSEN(30),IZ(30)
      DIMENSION IOPT(60)                                              INPOU  37
      DIMENSION KSV(10),KMII(12)                                      INPOU  38
      EQUIVALENCE (DH1,DH12(1)),(DH2,DH12(2)),(TS,TA(1))
  506 FORMAT (11X8HREACTION2X4HRHO05X4HRHOR8X1HB7X3HPSI8X1HE6X6HT REAC/2INPOU  49
     13X10H(LB/CU FT)6X7H(1/SEC)12X7H(DEG R)3X7H(DEG R))              INPOU  50
  507 FORMAT (14XA1,2XF9.2,2XE10.4,F7.2,2XE10.4,F8.0)                 INPOU  51
  510 FORMAT(12X31HRESIN VOLUME FRACTION, GAMMA = F5.3,17H(MASS FRACTIONINPOU  52
     1 = F5.3,1H)/1H )                                                INPOU  53
  523 FORMAT (20XF9.2,7XF9.2,11XF9.2)                                 INPOU  74
  524 FORMAT(/7X28HENTHALPY DATUM TEMPERATURE =F9.3,1X11HDEG RANKINE)  INPOU  75
  536 FORMAT (6X,F8.2,8X,I2,4X,2(F8.2,3X),F9.6,2X,F8.5,3X,F8.3)       IN
```

```
  538 FORMAT(//2(/X30H---SURFACE EQUILIBRIUM DATA---)                          INPOU105
  571 FORMAT(I2,F10.5,F10.5,F10.8,F10.5,F10.5)
  580 FORMAT (8F10.5)                                                          INPOU151
  587 FORMAT(I2)
  588 FORMAT( 2G10.8)
  589 FORMAT( 35H  CONDUCTIVITY TABLE FOR GAP KEY = , I1, /
     1 30H    TEMP,R     K,BTU/(SEC-FT-F)      ,/(
     2  3X,F12.7,E15.5 )  )
 5790 FORMAT (6X,26HNO RADIUS CORRECTION ON CH)                                INPOU129
  742 FORMAT(615)                                                              INPOU789
28612 FORMAT(6X,36HFISSURE MODEL NOT USED FOR GAS TERMS)                       INPOU749
28138 FORMAT(6X,12HCHAR SWELL =F8.4,1X16H* CHAR THICKNESS)                     INPOU651
28136 FORMAT(6X,45HNO CHAR SWELL CORRECTION ON SURFACE RECESSION)              INPOU648
28132 FORMAT(6X,66HFISSURE MODEL USED FOR SURFACE ENERGY TERMS AND BLOWI       INPOU637
     1NG CORRECTION)                                                           INPOU638
 7902 FORMAT (/28X,24HDECOMPOSING BACK-UP NO. ,I1)                             INPOU220
      DATA BLANK,ASTER/1H ,1H*/                                                INPOU156
      NPG = 1
      NMG(1) = 1
      NPR = 1
      INPUT=5                                                                  INPOU157
      KOUT=6                                                                   INPOU158
      INCH=5                                                                   INPOU159
C
C     INPUT/OUTPUT                                                             INPOU163
C                                                                              INPOU164
    1 NPG=1                                                                    INPOU165
      WRITE (KOUT,551)NPG                                                      INPOU166
  551 FORMAT(1H1110X65H          CHARRING MATERIAL THERMAL RESPONSE AND AINPOU106
     1BLATION PROGRAM/73X4HPAGE13/1H 67X2A6)                                   INPOU107
      IBUG = 0
C     ---------- TITLE CARDS
C          RECORD(I) = ALPHANUMERIC TITLE
      READ  (     5, 499)            (RECORD(I), I=1,54)
  499 FORMAT (18A4,8X/18A4,8X/18A4,8X)
      WRITE (KOUT,502)(RECORD(I),I=1,54)
  502 FORMAT (6X18A4)
C     ---------- HEADINGS
      WRITE (KOUT,503)                                                         INPOU176
  503 FORMAT(//24X31H---REACTION KINETIC EQUATION---/1H )                      INPOU 43
      WRITE (KOUT,504)                                                         INPOU177
  504 FORMAT(10X67HDRHO/DTIME = GAMMA ( BA*EXP(-EA/T)RHOOA((RHOA-RHORA)/INPOU 44
     1RHOOA)**PSIA )/   21X56H+ GAMMA ( BB*EXP(-EB/T)RHOOB((RHOB-RHORB)/INPOU 45
     2RHOOB)**PSIB )/ 19X58H+(1-GAMMA)( BC*EXP(-EC/T)RHOOC((RHOC-RHORC)/INPOU 46
     3RHOOC)**PSIC ))                                                         INPOU 47
      WRITE (KOUT,505)                                                         INPOU178
  505 FORMAT(/24X32H---REACTION KINETIC CONSTANTS---/1H )                      INPOU 48
      WRITE (KOUT,506)                                                         INPOU179
C     ---------- READ PARAMETERS FOR INTERNAL-DECOMPOSITION
C     A9,B9,C9 = MATERIAL COMPONENT
C     RHOOA,RHOOB,RHOOC = INITIAL DENSITY OF COMPONENT I
C     RHORA,RHORB,RHORC = RESIDUAL DENSITY OF COMPONENT I
C     BA,BB,BC = PRE-EXPONENTIAL FACTOR
C     PSIA,PSIB,PSIC = DENSITY FACTOR EXPONENT
C     EA,EB,EC = ACTIVATION ENERGY FACTOR
C     TRACA,TRACB,TRACC = MINIMUM TEMPERATURE OF REACTION ZONE
C     IDRD = ?
C     NOBU = NUMBER OF DECOMPOSING BACKUPS
C
      READ (INPUT,564) A9,RHOOA,RHORA,BA,PSIA,EA,TRACA,IDRD,
```

```
     1 B9,RHOOB,RHORB,BB,
     1  PSIB,EB,TRACB ,C9,RHOOC,RHORC,BC, PSIC,EC,TRACC,NDBU
  564 FORMAT(A1,9X,2F10.5,E10.3,F10.5,E10.3,F10.5,I1/A1,9X,2F10.5,E10.3,
     1F10.5, E10.3,F10.5/A1,9X,2F10.5,E10.3,F10.5,E10.3,F10.5,9X,I1)
      WRITE (KOUT,507)A9,RHOOA,RHORA,BA,PSIA,EA,TRACA,B9,RHOOB,RHORB,BB,INPOU182
     1PSIB,EB,TRACB ,C9,RHOOC,RHORC,BC, PSIC,EC,TRACC                    INPOU183
C     ---------- READ OUTPUT INTERVALS
C     JF = NUMBER OF NODELETS PER NODE
C     NUMN = TOTAL NUMBER OF NODES
C     NN = SWITCH FOR THERMOCOUPLE AND ISOTHERM OUTPUT
C     NO = NUMBER OF THERMOCOUPLES FOR WHICH OUTPUT IS DESIRED
C     NI = NUMBER OF ISOTHERMS FOR WHICH OUTPUT IS DESIRED
C     THZRO = INITIAL VALUE OF TIME
C     THFIN = FINAL VALUE OF TIME
C     DTPRT,DTPR2,DTPR3 - OUTPUT TIME INTERVALS
C     DTHB = MAXIMUM TIME STEP PERMITTED; DEFAULTS TO 5.0 SECONDS
C     BRP = BLOWING PARAMETER; BRP < 0 - PUTZ & BARTLETTE CORRELATION
C           BRP > 0 - OVERRIDES ZERO VALUE IN TABLES
C           BRP = 0.5 - MICKLEY & SPAULDING CORRELATION
C     TPR2,TPR3 = TIME OF TRANSITION FROM INTERVAL TO INTERVAL
C     DELM = MINIMUM THICKNESS OF LAST ABLATOR NODE
C     DH1,DH2,DELHG = HEAT OF FORMATION OF VIRGIN PLASTIC, CHAR
C                     AND THE PYROLYSIS ZONE
C     GAMA = VOLUME FRACTION OR MASS FRACTION OF THE VIRGIN PLASTIC
C            WHICH IS OCCUPIED BY RESIN. NEGATIVE GAMA IS MASS FRACTION
C     TZ = DATUM TEMPERTURE OF RHEATS OF FROMATION
C
      READ (INPUT,563) JF,NUMN,NN,NO,NI,THZRO,THFIN,DTPRT,DTPR2,DTPR3,   INPOU184
     1DTHB,BRP,TPR2,TPR3,DELM,DH1,DH2,DELHG,GAMA,TZ                      INPOU185
  563 FORMAT (I2,I3,I1,I2,I2,7F10.5/8F10.5)                             INPOU121
C     ----------
      IF(IDRD.EQ.0) GO TO 173
      READ(5,580) RA1,RA2,RA3
      WRITE(6,585) RA1,RA2,RA3
  585 FORMAT(46H  CHAR DENSITY A FUNCTION OF TEMPERATURE RATE    ,/
     1         46H    RHOC/RHOP= RA1+RA2/(RA3-LN(DT/DTIME))          ,/
     2   6H  RA1=,F12.7, 6H  RA2=,F12.7, 6H  RA3=,F12.7)
  173 IF (JF-1) 171,170,172
  170 JF=2                                                              INPOU187
      GO TO 172                                                         INPOU188
  171 JF=10                                                             INPOU189
  172 JFH=JF/2                                                          INPOU190
      JF=JFH+JFH                                                        INPOU191
      JFHP=JFH+1                                                        INPOU192
      FJFS=JF                                                           INPOU193
      FJFH=FJFS/2.0                                                     INPOU194
      NOI=NO+NI                                                         INPOU195
      IF (NO.GT.0) READ(5,580)(SO(I),I=1,NO)
      IF(NI.LE.0) GO TO 184
      NOP=NO+1
      READ (INPUT,580) (SO(I), I=NOP,NOI)                               INPOU201
  184 IF(GAMA.LT.0.0)
     1GAMA=RHOOC/(RHOOC-(RHOOA+RHOOB)-(RHOOA+RHOOB)/GAMA)
      ONG=1.0-GAMA
C     ---------- INSTANTANEOUS DENSITY OF COMPOSITE
      RHO(1)=GAMA*(RHOOA+RHOOB)+ONG*RHOOC                               INPOU205
      RHO(2)=GAMA*(RHORA+RHORB)+ONG*RHORC                               INPOU206
       GAMAM=GAMA/RHO(1)*(RHOOA+RHOOB)                                  INPOU207
      WRITE (KOUT,510)GAMA,GAMAM                                        INPOU208
      IF(NDBU.EQ.0) GO TO 701
```

```
      WRITE(6    ,79( ))
 7900 FORMAT (/23X,34H---DECOMPOSING BACK-UP KINETICS---/)                  INPOU211
C
C     ---------- LOOP FOR DECOMPOSING BACKUP MATERIALS
C
      DO 704 I=1,NDBU                                                      INPOU212
      READ(INPUT,5640)A9,RHOO(I,1),RHOR(I,1),BBB(I,1),PSI(I,1),EE(I,1),    INPOU213
     1TRAC(I,1),B9,RHOO(I,2),RHOR(I,2),BBB(I,2),       PSI(I,2),EE(I,2INPOU214
     2),TRAC(I,2),C9,RHOO(I,3),RHOR(I,3),BBB(I,3),PSI(I,3),EE(I,3),TRAC(INPOU215
     3I,3)                                                                INPOU216
 5640 FORMAT (A1,9X2F10.5,E10.3,F10.5,E10.3,F10.5)                        INPOU124
      READ(INPUT,7901) DHV(I),DHC(I),GA(I),TREF(I)                        INPOU217
 7901 FORMAT (30X,2F10.5,10X,2F10.5)                                      INPOU218
      WRITE(KOUT,7902) I                                                  INPOU219
      WRITE(KOUT,506)                                                     INPOU221
      WRITE(KOUT,507) A9,RHOO(I,1),RHOR(I,1),BBB(I,1),PSI(I,1),EE(I,1),   INPOU222
     1TRAC(I,1),B9,RHOO(I,2),RHOR(I,2),BBB(I,2),       PSI(I,2),EE(I,2INPOU223
     2),TRAC(I,2),C9,RHOO(I,3),RHOR(I,3),BBB(I,3),PSI(I,3),EE(I,3),TRAC(INPOU224
     3I,3)                                                                INPOU225
      IF (GA(I).LT.0.0)
     1GA(I)=RHOO(I,3)/(RHOO(I,3)- (RHOO(I,1)+RHOO(I,2))-(RHOO(I,1)+
     2RHOO(I,2))/GA(I))
      OMGA(I)=1.-GA(I)
      RHOV(I)=GA(I)*(RHOO(I,1)+RHOO(I,2))+OMGA(I)*RHOO(I,3)               INPOU230
      RHOC(I)=GA(I)*(RHOR(I,1)+RHOR(I,2))+OMGA(I)*RHOR(I,3)               INPOU231
      GAMAM=GA(I)/RHOV(I)*(RHOO(I,1)+RHOC(I,2))                           INPOU232
      WRITE(KOUT,510) GA(I),GAMAM                                         INPOU233
      P(I)=RHOV(I)/(RHOV(I)-RHOC(I))                                      INPOU234
      PP(I)=P(I)*RHOC(I)                                                  INPOU235
      DO 7030 J=1,3                                                       INPOU236
 7030 FF(I,J)=(1.-PSI(I,J))*BBB(I,J)*(RHOO(I,J)**(1.-PSI(I,J)))           INPOU237
  704 CONTINUE                                                            INPOU238
C
C     ---------- MAXIMUM TIME STEP DEFAULT TO 5.0 SECONDS
  701 IF(DTHB.EQ.0.0) DTHB=5.0
      DTHIN=.01
      IF(TPR2.LE.0.0) TPR2=THFIN
      IF(TPR3.GT.0.0) GO TO 417
  416 TPR3=THFIN                                                          INPOU246
      IF(TPR2.GT.THZRO) GO TO 417
      DTPRT=DTPR2
      DTPR2=DTPR3                                                         INPOU249
      TPR2=TPR3                                                           INPOU250
      GO TO 416                                                           INPOU251
C     ---------- ECHO TIME INTERVAL INFORMATION
  417 WRITE (KOUT,511)                                                    INPOU252
  511 FORMAT (24X32H---TIME INCREMENT INFORMATION---/1H )                 INPOU 54
      THFIN=AMAX1(THFIN,TPR2,TPR3)                                        INPOU253
      WRITE (KOUT,512)THZRO,THFIN                                         INPOU254
  512 FORMAT (6X18HINITIAL TIME (SEC)F9.2,26X16HFINAL TIME (SEC)F9.2)     INPOU 55
      WRITE (KOUT,513)DTPRT,TPR2                                          INPOU255
  513 FORMAT (1H /6X17HOUTPUT INTERVAL =F9.3,1X27HSEC FROM INITIAL TIME   INPOU 56
     1UNTIL F9.2,4H SEC)
      WRITE (KOUT,514)DTPR2,TPR2,TPR3                                     INPOU256
  514 FORMAT (6X17HOUTPUT INTERVAL =F9.3,1X8HSEC FROMF9.2,1X9HSEC UNTILF  INPOU 58
     19.2,4H SEC)
      WRITE (KOUT,515)DTPR3,TPR3                                          INPOU257
  515 FORMAT (6X17HOUTPUT INTERVAL =F9.3,1X8HSEC FROMF9.2,1X20HSEC UNTIL  INPOU 60
     1 FINAL TIME/1H )                                                    INPOU 61
      WRITE (KOUT,516) DTHB                                               INPOU258
```

```
  516 FORMAT (6X,19HMAXIMUM TIME STEP =,F9.3,8H SECONDS)
C     ----------
      TRACM=AMIN1(TRACA,TRACB,TRACC)                                    INPOU259
      PETE = 0.0
      ZZZ = RHO(1) - RHO(2)
      IF(ZZZ.NE.0.0) PETE = RHO(1)/ZZZ
      PET=PETE*RHO(2)                                                   INPOU261
C
C     ----------  NODAL PROPERTIES                                      INPOU262
C
      N=0                                                               INPOU263
      KHS=10                                                            INPOU264
      NDBUCH=0                                                          INPOU265
      J1=JFH                                                            INPOU266
      CALL LCOUNT (-NUMN-8,LCT,NPG)
      WRITE (   6,517)
  517 FORMAT(/29X16H---NODAL DATA---/1H )                               INPOU 63
      WRITE (   6,518)
  518 FORMAT(6X74HNODE  MATL  TEMPERATURE  RELATIVE  THICKNESS  NODAL DEINPOU 64
     1PTH  GAP       QGEN )
      WRITE (   6,519)
  519 FORMAT(7X95HNO.   NO. (DEG.RANKINE)   AREA    (INCHES)    (INCHES)INPOU 66
     1  INCHES    BTU/FT3-SEC  RRGAP  AGAP                    )
      B=ASTER                                                           INPOU271
C     ---------- READ NODAL DATA
C     MATL = MATERIAL NUMBER
C     TA = INITIAL TEMPERATURE
C     AREA = INITIAL CROSS-SECTIONAL AREA; BLANK IF RADIUS RELATED AREA
C     DEL = INITIAL THICKNESS OF NODE
C     RA = IDENTIFIES GEOMETRY TYPE
C     QGEN = HEAT GENERATION
C     LGAP = FLAG FOR GAP TYPE
C     GAP = GAP SIZE IN INCHES
C
      READ(    5,560)(MATL(I),TA(I),AREA(I),DEL(I),RA(I),QGEN(I),
     1 LGAP(I),GAP(I),I = 1,NUMN)
  560 FORMAT(I2,5E10.0,I1,E9.0)
C     ----------
      RC(I) = 0.0
      AE=RA(2)                                                          INPOU273
      RSV=RA(1)                                                         INPOU274
      RA(1)=0.0                                                         INPOU275
      RRGAP(1) = DEL(1)
C
C     ---------- PROCESS NODAL DATA
C
      DO 400 I=1,NUMN                                                   INPOU276
      IF(I-2) 4541,452,453                                              INPOU277
  453 RA(I)=RA(I-1)+(DEL(I-1)+DEL(I))/2.0  + GAP(I-1)
      RRGAP(I) = RA(I) + (GAP(I) + DEL(I))/2.0
      GO TO 461                                                         INPOU279
  452 RA(2)=DEL(1)+DEL(2)/2. + GAP(1)
      RRGAP(2) = RA(2) + (GAP(2) + DEL(2))/2.0
      B=BLANK                                                           INPOU281
  461 DEL(I-1)=DEL(I-1)/12.                                             INPOU282
      GAP(I-1) = GAP(I-1)/12.0
 4541 RAV(I)=RA(I)                                                      INPOU283
      IF(AE.EQ.0.0) GO TO 4543
      AREA(I)=(ABS(RSV+RA(I)))**AE                                      INPOU285
      AGAP(I)  = (ABS(RSV+RRGAP(I)))**AE
```

```
      GO TO 454                                                          INPOU286
 4543 IF(AREA(I).GT.0.0) GO TO 454
      IF(RSV.EQ.0.0) GO TO 4546
      AREA(I)=ABS(RSV+RA(I))
      AGAP(I)  =  ABS(RSV+RRGAP(I))
      AE=1.0                                                             INPOU290
      GO TO 454                                                          INPOU291
 4546 AREA(I)=1.                                                         INPOU292
      AGAP(I)  =  1.0
  454 QGEN(I) = QGEN(I)*1728.0
      WRITE(   6,520)I,MATL(I),TA(I),AREA(I),DEL(I),RA(I),GAP(I),
     1 LGAP(I),QGEN(I),RRGAP(I),AGAP(I)
  520 FORMAT(3X216,F12.2,E13.4,F9.5,F12.6,F9.6,1X,I1,F9.3,F9.6,F9.6)
      IF(LGAP(I).EQ.0) GO TO 455
      IF(LGAP(I).LE.4) WRITE(6,546)
  546 FORMAT(20H GAP GAS COND BELOW    )
      IF(LGAP(I).EQ.5) WRITE(6,547)
  547 FORMAT(18H AIR IN GAP            )
      IF(LGAP(I).EQ.6) WRITE(6,548)
  548 FORMAT(18H HELIUM IN GAP         )
      IF(LGAP(I).EQ.7) WRITE(6,549)
  549 FORMAT(18H NO GAS IN GAP         ;
  455 IF (MATL(I)-2) 401,405,705
  401 NL=I                                                               INPOU295
        DO 404 J=1,J1                                                    INPOU296
        N=N+1                                                            INPOU297
        RHOCI(I) = RHO(2)
        ROA(N)=RHOOA                                                     INPOU298
        ROB(N)=RHOOB                                                     INPOU299
  404   ROC(N)=RHOOC                                                     INPOU300
      J1=JF                                                              INPOU301
      GO TO 400                                                          INPOU302
  405 NL=I                                                               INPOU303
        DO 406 J=1,J1                                                    INPOU304
        N=N+1                                                            INPOU305
        ROA(N)=RHORA                                                     INPOU306
        ROB(N)=RHORB                                                     INPOU307
  406   ROC(N)=RHORC                                                     INPOU308
      J1=JF                                                              INPOU309
      GO TO 400                                                          INPOU310
  705 IF(MATL(I).LE.10) GO TO 400
C     ---------- PROCESS CHARRING BACKUP MATERIALS
      K=MATL(I)-21
      VKH=FLOAT(K)/2.0                                                   INPOU313
      KH=K/2                                                             INPOU314
      VKH2=KH
      IF(VKH.NE.VKH2) GO TO 708
      ROCOM(I,1)=RHOR(KH,1)
      ROCOM(I,2)=RHOR(KH,2)                                              INPOU317
      ROCOM(I,3)=RHOR(KH,3)                                              INPOU318
      X(I)=0.                                                            INPOU319
      GO TO 709                                                          INPOU320
  708 KH=KH+1                                                            INPOU321
      ROCOM(I,1)=RHOO(KH,1)                                              INPOU322
      ROCOM(I,2)=RHOO(KH,2)                                              INPOU323
      ROCOM(I,3)=RHOO(KH,3)                                              INPOU324
      X(I)=1.0                                                           INPOU325
  709 IF(KH.EQ.KHS) GO TO 7092
      NFI(KH)=I
      KHS=KH                                                             INPOU328
```

```
      NDBUCH=NDBUCH+1                                                    INPOU329
 7092 NLA(KH)=I                                                          INPOU330
  400 CONTINUE                                                           INPOU331
C
C     PROCESS BACKUP MATERIALS
C
      IF(NDBU-NDBUCH) 7095,403 ,7093
 7095 WRITE(KOUT,7096)                                                   INPOU333
 7096 FORMAT(10X,55HTOO MANY DECOMPOSING BACK-UPS IN NODAL DATA -- QUIT  INPOU334
     1JOB)
      STOP                                                               INPOU336
 7093 WRITE(KOUT,7097)                                                   INPOU337
 7097 FORMAT(10X,54HTOO FEW DECOMPOSING BACK-UPS IN NODAL DATA -- QUIT J
     10B)
      STOP                                                               INPOU340
  403 DEL(NUMN)=DEL(NUMN)/12.                                            INPOU342
      GAP(NUMN) = GAP(NUMN)/12.0
      CALL SLOPQ(NUMN,RA,AREA,EMA)                                       INPOU343
      NBM=NL+1                                                           INPOU344
      IF(NDBU.EQ.0) GO TO 7099
      NBM2=NLA(NDBU)+1
      GO TO 7091                                                         INPOU347
 7099 NBM2=NBM                                                           INPOU348
 7091 CONTINUE                                                           INPOU349
      IF(RSV) 4031,4032,4033                                             INPOU350
 4031 RSVN=-RSV                                                          INPOU351
      WRITE(KOUT,554)RSVN,AE                                             INPOU352
  554 FORMAT(8X24H*INITIAL EXTERNAL RADIUS,1X,F6.3,4X,21HAREA PROP.TO RAINPOU113
     1DIUS**F4.2)                                                        INPOU114
      GO TO 304                                                          INPOU353
 4032 WRITE(KOUT,555)                                                    INPOU354
  555 FORMAT(8X15H*PLANAR SURFACE)                                       INPOU115
      GO TO 304                                                          INPOU355
 4033 WRITE(KOUT,553)RSV,AE                                              INPOU356
  553 FORMAT(8X24H*INITIAL INTERNAL RADIUS,1X,F6.3,4X,21HAREA PROP.TO RAINPOU111
     1DIUS**F4.2)                                                        INPOU112
  304 WRITE (KOUT,521) DELM,JF                                           INPOU357
  521 FORMAT (     14X47HMINIMUM THICKNESS OF LAST ABLATOR NODE (INCHES)FINPOU 69
     17.4/14X,10HTHERE ARE ,I2,40H NODELETS ASSIGNED TO EACH ABLATING NOINPOU 70
     2DE)                                                                INPOU 71
      DELM=DELM/12.0                                                     INPOU358
C     ---------- READ BACKWALL HEAT TRANSFER
C     IBF = NUMBER OF TABULAR ENTRIES
C     HCONV = BACKWALL CONVECTIVE COEFFICIENT
C     EPSW = BACKWALL EMMISIVITY; RADIATES TO ZERO DEG R
C     TRES = RESERVOIR TEMPERATURE FOR CONVECTION
C     CHCRI = CHAR ZONE CRITERIA (RC)
C     PYCRI = PYROLYSIS ZONE CRITERIAL (RP)
C     NCON = OUTPUT THERMAL CONDUCTIVITY INSTEAD OF ENTHALPY
C
      READ(5,582) IBF,HCONV,EPSW,TRES,CHCRI,PYCRI,NCON
  582 FORMAT(I2,F8.5,4F10.5,9X,I1)
      IF (IBF.EQ.0) GO TO 305
C     ---------- READ TIME DEPENDENT BACKWALL HEAT TRANSFER TABLE
C     TQ = TIME
C     THCONV = BACKWALL CONVECTIVE COEFFICIENT
C     TEPSW = BACKWALL EMISSIVITY FOR RADIATION TO ZERO DEG R
C     TEPSD = BACKWALL EMISSIVITY FOR RADIATION TO TTRES
C     TTRES = RESERVOIR TEMPERATURE
C
```

```
      DO 306 I = 1,IBF
      READ(5,590) TQ(I),THCONV(I),TEPSW(I),TEPSD(I),TTRES(I)
  590 FORMAT(5F10.5)
  306 CONTINUE
      GO TO 307
C
  305   DO 308 I= 1,2
        THCONV(I)=HCONV
        TEPSW(I) =EPSW
        TEPSD(I) = 0.0
        TTRES(I) =TRES
  308   CONTINUE
      TQ(1)=THZRO
      TQ(2)=THFIN
      IBF=2
  307 IF (CHCRI.LE.0.0) CHCRI=0.02
      IF (PYCRI.LE.0.0) PYCRI=0.98
      TA(NUMN+1)=TRES
      CALL LCOUNT(4,LCT,NPG)
      WRITE(KOUT,581) HCONV,EPSW,TRES                                    INPOU366
  581 FORMAT(/14X20HBACK WALL CONVECTION10X9HBACK WALL10X9HRESERVOIR/    INPOU152
     113X23HCOEF BTU/FTSQ-SEC-DEG R8X10HEMISSIVITY8X11HTEMPERATURE/     INPOU153
     217XF10.4,18XF6.3,10XF10.2)                                        INPOU154
      WRITE(6,591)
  591 FORMAT(20H BACKWALL CONDITIONS  /
     1 57H   TIME(SEC)  CH(BTU/S/F2/R)  EMSW     EMSD     TRES(R)    )
        DO 309 I = 1,IBF
        WRITE(6,592) TQ(I),THCONV(I),TEPSW(I),TEPSD(I),TTRES(I)
  592   FORMAT( F8.2,F14.4,F13.3,F13.3,F10.1)
  309   CONTINUE
C
      CALL LCOUNT(5,LCT,NPG)
      WRITE (KOUT,522)                                                   INPOU368
  522 FORMAT(/18X48H---HEAT OF FORMATION OF MATERIAL CONSTITUENTS---/37XINPOU 72
     18H(BTU/LB)/21X7HPLASTIC11X4HCHAR17X3HGAS)                         INPOU 73
      WRITE (KOUT,523)DH1,DH2,DELHG                                      INPOU369
      CALL LCOUNT(2,LCT,NPG)
C     ---------- WRITE OUT ENTHALPY DATUM TEMPERATURE
      WRITE (KOUT,524)TZ                                                 INPOU371
      IF (NDBU.LE.0) GO TO 7910
        DO 7908 J=1,NDBU
        CALL LCOUNT(8,LCT,NPG)
        WRITE(KOUT,7902) J                                               INPOU375
 7909   FORMAT(/21X7HPLASTIC11X4HCHAR17X3HGAS)                           INPOU376
        WRITE(KOUT,7909)                                                 INPOU377
        WRITE(KOUT,523) DHV(J),DHC(J),DELHG                              INPOU378
 7908   WRITE(KOUT,524) TREF(J)                                          INPOU379
C
C     --------- MATERIAL PROPERTIES                                      INPOU381
C
 7910 CALL LCOUNT(6,LCT,NPG)
      WRITE (KOUT,525)
  525 FORMAT    (//22X36H---MATERIAL THERMAL PROPERTY DATA---//6X14HMATERINPOU 76
     1IAL NO. 110X14HMATERIAL NO. 210X26HMATERIAL NOS. 3 THROUGH 10/6X14INPOU 77
     2HVIRGIN PLASTIC15X4HCHAR23X7HBACK-UP)                             INPOU 78
      CALL LCOUNT(3,LCT,NPG)
      WRITE(KOUT,7905)                                                   INPOU385
 7905 FORMAT(/3X,82HDECOMPOSING BACK-UP VIRGIN MATERIALS 22,24,26,28,30,INPOU386
     1 CHAR MATERIALS 23,25,27,29,31)                                    INPOU387
      IT=0                                                               INPOU388
```

```
      ILO(3)=1                                                          INPOU389
      ILO(4)=1                                                          INPOU390
      KT=1                                                              INPOU391
  350 IT=IT+1                                                           INPOU392
C     ---------- READ MATERIAL PROPERTY TABLES
C     NC = FLAG TO MARK END OF MATERIAL TABLE
C     TT2 = TEMPERATURE
C     TCP = SPECIFIC HEAT
C     TKP = THERMAL CONDUCTIVITY
C     TEP = EMISSIVITY OF FRONT FACE
C     TEPBF = EMISSIVITY OF BACK FACE
C
      READ (INPUT,571) NC,TT2(IT,KT),TCP(IT,KT),TKP(IT,KT),TEP(IT,KT),
     1 TEPBF(IT,KT)
      IF (NC.EQ.0) GO TO 350
      IHI(KT+2)=ILO(KT+2)+IT-1
      IR(KT+2)=ILO(KT+2)                                                INPOU396
      THZ(1,KT)=0.                                                      INPOU397
C     ---------- COMPUTE ENTHALPY
      DO 357 I=2,IT                                                     INPOU398
  357 THZ(I,KT)=THZ(I-1,KT)+(TCP(I,KT)+TCP(I-1,KT))/2.*(TT2(I,KT)-TT2(I-INPOU399
     11,KT))                                                            INPOU400
      CALL LOOK (KT+2,TZ,TT2(1,KT),THZ(1,KT),0,0,0,HSH,DUM,1)           INPOU401
C     ---------- REFERENCES ZERO ENTHALPY AT DATUM TEMPERATURE, TZ
        DO 359 I=1,IT                                                   INPOU402
  359   THZ(I,KT)=THZ(I,KT)-HSH                                         INPOU403
      CALL LCOUNT(6+IT,LCT,NPG)
C     ---------- ECHO MATERIAL PROPERTY INPUT
      WRITE(KOUT,526)KT,RHO(KT),(TT2(I,KT),TCP(I,KT),TKP(I,KT),THZ(I,KT)INPOU405
     1,TEP(I,KT),TEPBF(I,KT),I=1,IT)
  526 FORMAT(/6X12HMATERIAL NO.12,30X9HDENSITY =F8.3,1X8HLB/CU FT/      INPOU 79
     1        7X11HTEMPERATURE5X13HSPECIFIC HEAT5X12HCONDUCTIVITY5X8HSENINPOU 80
     2SIBLE4X5HEMISS,5X,5HEMISS /58X,8HENTHALPY,4X,5HFRONT,5X,4HBACK/
     3 9X,7H(DEG R),7X,12H(BTU/LB-DEG),4X,16H(BTU/FT-SEC-DEG),
     4 3X,8H(BTU/LB)/
     5       (8XF8.2,8XF7.4,9XF10.7,7XF9.2,4XF7.4,4X,F7.4))
      KT=KT+1                                                           INPOU407
      IT=0                                                              INPOU408
      IF (NC.GE.0) GO TO 353
      IF (KT.LE.2) GO TO 350
      IF (NDBU.EQ.0) GO TO 4110
      I=1
C
C     ----------  PROCESS DECOMPOSING BACKUP MATERIALS
C
      DO 720 K=1,NDBU                                                   INPOU413
      IT=0                                                              INPOU414
  712 IT=IT+1                                                           INPOU415
      READ(INPUT,571) NC,TT5(IT,I),TCBU(IT,I),TKBU(IT,I)                INPOU416
      IF(NC) 713,712,713                                                INPOU417
  713 IHI(I+21)=IT                                                      INPOU418
      ILO(I+21)=1                                                       INPOU419
      IR(I+21)=1                                                        INPOU420
      TENT(1,I)=0.                                                      INPOU421
      DO 714 J=2,IT                                                     INPOU422
  714 TENT(J,I)=TENT(J-1,I)+(TCBU(J,I)+TCBU(J-1,I))/2.*(TT5(J,I)-TT5(J-1INPOU423
     1,I))                                                              INPOU424
      CALL LOOK(21+I,TREF(K),TT5(1,I),TENT(1,I),0,0,0,HSH,DUM,1)        INPOU425
      DO 715 J=1,IT                                                     INPOU426
  715 TENT(J,I)=TENT(J,I)-HSH                                           INPOU427
```

```
      IF(2*K-1) 717,716,717                                              INPOU428
  716 RRR=RHOC(K)                                                        INPOU429
      GO TO 718                                                          INPOU430
  717 RRR=RHOV(K)                                                        INPOU431
  718 CALL LCOUNT(6+IT,LCT,NPG)
      L=I+21                                                             INPOU433
      WRITE(KOUT,5260)   L,RRR,(TT5(J,I),TCBU(J,I),TKBU(J,I),TENT(J,I),  INPOU434
     1J=1,IT)                                                            INPOU435
 5260 FORMAT(/6X12HMATERIAL NO.I2,30X9HDENSITY =F8.3,1X8HLB/CU FT/       INPOU 84
     1        7X11HTEMPERATURE5X13HSPECIFIC HEAT5X12HCONDUCTIVITY5X8HSEN INPOU 85
     2SIBLE                /58X8HENTHALPY/9X7H(DEG R)7X12H(BTU/LB-DEG)4X1INPOU 86
     36H(BTU/FT-SEC-DEG)3X8H(BTU/LB)/                                    INPOU 87
     4       (8XF8.2,8XF7.4,9XF10.7,7XF9.2       ))                     INPOU 88
      I=I+1                                                              INPOU436
      IT=0                                                               INPOU437
      IF (NC.GE.0) GO TO 353
      IF (2*K-1.EQ.0) GO TO 712
  720 CONTINUE                                                           INPOU440
C
 4110 IN=0                                                               INPOU441
      L=0                                                                INPOU442
C     ---------- F-FUNCTION TABLE LEAD LINE
  411 READ(INPUT,561) KT,LEMB,RHO(KT),(KMTL(I),I=1,6)
  561 FORMAT(I2,I1,F7.4,6I1)
      IF(RHO(KT)) 3550,3550,355                                          INPOU444
 3550 LL=1                                                               INPOU445
      L=L+1                                                              INPOU446
      JBU=0                                                              INPOU447
      IF (KMTL(1).GT.0) GO TO 3559
      WT=FLOAT(L)
      IN=1                                                               INPOU450
      LL=2                                                               INPOU451
 3559   DO 3554 I=LL,6                                                  INPOU452
        IF (KMTL(I).LE.0) GO TO 3554
        JBU=JBU+1
        KSV(JBU)=KMTL(I)                                                 INPOU455
        J=KMTL(I)                                                        INPOU456
        NBUFT(J)=L                                                       INPOU457
 3554   CONTINUE                                                         INPOU458
      IF(JBU.LE.0) GO TO 3540
      CALL ORDERI(JBU,KSV)
 3540 IX=0                                                               INPOU461
 3551 IX=IX+1                                                            INPOU462
C     ---------- F-FUNCTION TABLE
      READ(INPUT,497) NC,TX(IX,L),F1(IX,L),F2(IX,L)                      INPOU463
  497 FORMAT(I2,3F10.5)                                                  INPOU 40
      IF (NC.EQ.0) GO TO 3551
      ILO(L+31)=1
      IHI(L+31)=IX
      IR(L+31)=1
      CALL LCOUNT(5+IN+JBU+4*(1-(L+2)/4),LCT,NPG)
      IF (L.LE.1) WRITE(6,495)
  495 FORMAT(//7X,67HTABLES OF OPTIONAL MASS-FRACTION FUNCTIONS FOR THERINPOU479
     1MAL CONDUCTIVITY/25X,23HK = F1(X)*KP + F2(X)*KC)                   INPOU480
      WRITE(KOUT,496) L
  496 FORMAT(/23X,21HF-FUNCTION TABLE NO. ,I1,12H ASSIGNED TO)           INPOU481
      IF (IN.GT.0) WRITE(6,4971)
 4971 FORMAT(34X,13HMAIN MATERIAL)                                       INPOU482
      IF (JBU.GT.0) WRITE(6,4981)(KSV(I),I=1,JBU)
 4981 FORMAT(28X,24HDECOMPOSING BACK-UP NO. ,I1)                         INPOU483
```

```
      WRITE(KOUT,494) (TX(I,L),F1(I,L),F2(I,L),I=1,IX)
  494 FORMAT(/25X,1HX,12X,5HF1(X),10X,5HF2(X)//(13X,3(5X,F10.4)))          INPOU478
      IN=0                                                                 INPOU477
      IF (NC) 411,411,353                                                  INPOU484
  355 IT=IT+1                                                              INPOU485
C     ---------- READ BACKUP MATERIAL PROPERTIES
      READ (INPUT,571) NC,TT2(IT,KT),TCP(IT,KT),TKP(IT,KT) ,TEP(IT,KT),
     1  TEPBF(IT,KT)
      IF(LEMB.EQ.0) TEPBF(IT,KT) = TEP(IT,KT)
      IF (NC.EQ.0) GO TO 355
      ILO(KT+2)=1
      IHI(KT+2)=ILO(KT+2)+IT-1                                             INPOU489
      IR(KT+2)=ILO(KT+2)                                                   INPOU490
      CALL LCOUNT(5+IT,LCT,NPG)
C     ---------- ECHO BACKUP MATERIAL PROPERTIES
      WRITE (KOUT,527) KT,RHO(KT),(TT2(I,KT),TCP(I,KT),TKP(I,KT),
     1 TEP(I ,KT), TEPBF(I ,KT), I = 1,IT)
  527 FORMAT(/6X12HMATERIAL NO.I2,30X9HDENSITY =F8.3,1X8HLB/CU FT/       INPOU 89
     1        7X11HTEMPERATURE5X13HSPECIFIC HEAT5X,7HCONDUCT,5X,
     2 5HEMISS,5X,5HEMISS/9X,7H(DEG R),
     3     7X12H(BTU/LB-DEG)4X16H(BTU/FT-SEC-DEG),1X,5HFRONT,2X,4HBACK/
     4       (8XF8.2,8XF7.4,9XF10.7,4X,F7.4,4X,F7.4))
      IT=0                                                                 INPOU493
      IF (NC.LE.0) GO TO 411
C     ----------  PYROLYSIS GAS ENTHALPY                                   INPOU495
  353 NT1=0
  361 IN=1+NT1                                                             INPOU497
      NT1=8+NT1                                                            INPOU498
      READ  (INPUT,575)NC,(TT1(I),I=IN,NT1),(THG(I),I=IN,NT1)              INPOU499
  575 FORMAT(I1,F9.5,7F10.5/8F10.5)                                        INPOU126
      IF(NC)361,361,362                                                    INPOU500
  364 NT1=NT1-1                                                            INPOU501
  362 IF (TT1(NT1).LE.0.0) GO TO 364
      ILO(2)=1
      IR(2)=1                                                              INPOU504
      IHI(2)=NT1                                                           INPOU505
      CALL LCOUNT(3*((NT1+9)/5),LCT,NPG)
C     ---------- DISPLAY RESIN DECOMPOSITION TABLE
      WRITE (KOUT,532)
  532 FORMAT   (//20X47H---RESIN DECOMPOSITION GAS SENSIBLE ENTHALPY---)INPOU 94
      IFN=0                                                                INPOU508
  368 IN=IFN+1                                                             INPOU509
      IFN=MINO(NT1,IFN+5)                                                  INPOU510
      WRITE (KOUT,531)(TT1(I),I=IN,IFN )                                   INPOU511
  531 FORMAT (1H /6X19HTEMPERATURE (DEG R)5F11.2)                          INPOU 93
      WRITE (KOUT,533)(THG(I),I=IN,IFN)                                    INPOU512
  533 FORMAT     (6X19HENTHALPY   (BTU/LB)5F11.2)                          INPOU 95
      IF (NT1.GT.IFN) GO TO 368
C
C     ----------  FUNCTIONS OF TIME                                        INPOU514
C
      NTH=0
      IS=0                                                                 INPOU516
      NOPT=0                                                               INPOU517
      CALL LCOUNT(-3,LCT,NPG)
      WRITE(6,545)
  545 FORMAT(26X,  46H--INPUT TIME DEPENDENT BOUNDARY CONDITIONS--   /)
C     ---------- READ SURFACE BOUNDARY CONDITIONS
C     RADUS = NOSE RADIUS USED TO MODIFY CONV. AND RAD. HEAT TRANSFER
C             BY (RN)**-0.5
```

```
C      QFC = CONVECTIVE HEAT TRANSFER FACTOR
C      QFR = RADIATIVE HEAT TRANSFER FACTOR
C      QFF = FREE MOLECULAR FLOW HEAT TRANSFER FACTOR
C      QFP = SURFACE PRESSURE FACTOR
C      IEROS = IF NOT ZERO, USES LUNDELL & DICKEY EROSION MODEL
C      IBPRD = NOT USED
C      ISR = IF NOT ZERO, NO SURFACE RECESSION ALLOWED, BUT BLOWING AND
C            ENERGY LOSS TERMS INCLUDED
C      ICOND = NUMBER OF GAS CONDUCTIVITY TABLES FOR GAPS
C      IBUG = DEBUG OUTPUT SWITCH ( 0 = NO DEBUG OUTPUT)
C      TBUG = TIME IN WHICH THE DEBUG OUTPUT STARTS
C
       READ(5,540) RADUS,QFC,QFR,QFF,QFP,IEROS,IBPRD,ISR,ICOND,IBUG,TBUG
  540  FORMAT( 5F10.0,5I2, F10.0)
       WRITE(6,541) RADUS, QFC, QFR, QFF,QFP
  541  FORMAT( 26H --INPUT TIME TABLES----- /
      1 18H NOSE RADIUS(IN) = , F10.4 , 5X,15HQCOND FACTOR  = , F10.4 /
      2 18H QRAD FACTOR     = , F10.4 , 5X,15HQFMF  FACTOR  = , F10.4 /
      3 18H PRESS FACTOR    =  , F10.4  )
C       ---------- CONVERSION FOR RADIUS
       FACT1 = SQRT(RADUS/12.0)
       WRITE(6,542)
  542  FORMAT(
      C      41H   TIME      VEL     ALT       HT          PT ,
      1         38H        QRAD   QCOND   QFMF        BP     /
      2      41H    SEC      FPS     KFT    BTU/LB       ATM ,
      3         38H      ------BTU/LB/FT**2------             )
  371 NTH=NTH+1                                                          INPOU518
C      ---------- SURFACE BOUNDARY CONDITIONS TIME-TABLE
C      NC = FLAG TO INDICATE LAST LINE OF TIME TABLE
C      TTH = TIME
C      THE =    OPTION 1: RECOVERY ENTHALPY
C                      2: SURFACE TEMPERATURE
C                      3: RADIATION VIEW FACTOR
C      XQRAD = OPTION 1: RADIANT ENERGY FLUX TO SURFACE
C                      2: SURFACE RECESSION RATE
C                      3: RADIANT ENERGY FLUX TO SURFACE
C      XQCO =   OPTION 1: CONVECTIVE ENERGY FLUX TO COLD SURFACE
C                      2: < 0.0 INVOKES OPTION 2
C                      3: = 0.0 INVOKES OPTION 3
C      XQFM =   OPTION 1: FREE MOLECULAR ENERGY FLUX TO SURFACE
C                      2: BLANK
C                      3: BLANK
C      TPI =    OPTION 1: SURFACE PRESSURE
C                      2: BLANK
C                      3: BLANK
C      TALT = ALTITUDE
C      TVEL = VELOCITY
C      TBRP = BLOWING REDUCTION PARAMETER IF TIME DEPENDENT.
C             BLANKS WILL BE FILLED BY CONSTANT VALUES FROM ABOVE
C             OR BY PUTZ AND BARTLETTE CORRELATION.
C
       READ(5,577) NC,TTH(NTH),THE(NTH),XQRAD,XQCO,XQFM,TPI(NTH),
      1          TALT(NTH),TVEL(NTH),TBRP(NTH)
  577  FORMAT(I1,F9.2,F10.1,3F10.2,F10.5,F6.1,F7.1,F7.2 )
       WRITE(6,543) TTH(NTH),TVEL(NTH),TALT(NTH),THE(NTH),TPI(NTH),
      1 XQRAD,XQCO,XQFM,TBRP(NTH)
  543  FORMAT(1X,F7.1,F8.0,F8.2,F11.1,F10.5,F9.1,F8.1,F8.1,F6.1)
C       ---------- ADJUST TIME TABLE VALUES USING FACTORS
       TPI(NTH) = TPI(NTH)*QFP
```

```
      XQFM      = XQFM*QFF
      TQR(NTH) = XQRAD*FACT1*QFR
      TALT(NTH) = TALT(NTH)*1000.0
      TCM(NTH) = XQCO*QFC/FACT1
      IF(XQFM.LE.0.0) GO TO 190
      IF (XQFM/XQCO.GT.10.0) GO TO 190
C     ---------- BRIDGING FREE MOLECULAR TO CONTINUUMCONVECTION
      TCM(NTH) = TCM(NTH)*(1.0 - EXP(-XQFM/TCM(NTH)))
  190 IF(THE(NTH).NE.0.0) TCM(NTH)=TCM(NTH)/THE(NTH)
      IF (TBRP(NTH).EQ.0.0) TBRP(NTH) = BRP
C     ( II = PROBLEM OPTION SELECTION BASED ON TIME-TABLE INPUT)
      II=1
      IF(TCM(NTH).GT.0.0) GO TO 343
      II=2
      IF (THE(NTH).EQ.0.0) II=3
  343 IOPT(NTH)=II
      IF (II.EQ.IS) GO TO 346
      NOPT=NOPT+1
      IS=II                                                          INPOU531
C
C     (1/16/87) TIME-TABLE LENGTH CHANGED TO 120
C
      IF(NTH.LE.120) GO TO 346
      WRITE(6,544)
  544 FORMAT( 35H ----TOO MANY TIME TABLE POINTS----     )
      STOP
  346 IF(NC.LE.0) GO TO 371
      ILO(1)=1
      IHI(1)=NTH                                                     INPOU534
      IR(1)=ILO(1)                                                   INPOU535
      CALL LCOUNT(-4,LCT,NPG)
      WRITE (KOUT,534)                                               INPOU537
  534 FORMAT (1H //23X40H---TIME DEPENDENT BOUNDARY CONDITIONS---/1H ) INPOU 96
      IS=0                                                           INPOU538
      DO 3476 I=1,NTH                                                INPOU539
      II=IOPT(I)                                                     INPOU540
      IF (II.EQ.IS) GO TO 349
      IS=II
      GO TO (3471,3472,3473),II                                      INPOU543
 3471 WRITE(KOUT,535)                                                INPOU544
  535 FORMAT (9X,4HTIME,8X,4HPROB,3X,8HRECOVERY,3X,9HRADIATION,4X,4HHEATINPOU 97
     15X,8HPRESSURE,3X,7HBLOWING/9X,5H(SEC),7X,4HOPTN,3X,8HENTHALPY,3X, INPOU 98
     29HHEAT RATE,4X,5HCOEFF,14X,9HREDUCTION/28X,8H(BTU/LB),2X,11H(BTU/SINPOU 99
     3Q FT-,1X,10H(LB/SQ FT-,3X,5H(ATM),3X,9HPARAMETER /40X,7HSECOND), INPOU100
     44X,7HSECOND))                                                 INPOU101
      GO TO 3474                                                     INPOU545
 3472 WRITE(KOUT,552)                                                INPOU546
  552 FORMAT (9X,4HTIME,8X,4HPROB,3X,7HSURFACE,4X,7HSURFACE/9X,5H(SEC), INPOU108
     17X,4HOPTN,5X,4HTEMP,5X,9HRECESSION/28X,7H(DEG R),6X,4HRATE/38X, INPOU109
     210H(MILS/SEC))                                                INPOU110
      GO TO 3475                                                     INPOU547
 3473 WRITE(KOUT,556)                                                INPOU548
  556 FORMAT (9X,4HTIME,8X,4HPROB,5X,4HVIEW,5X,9HRADIATION/9X,5H(SEC), INPOU116
     17X,4HOPTN,4X,6HFACTOR,4X,9HHEAT RATE/38X,11H(BTU/SQ FT-/40X, INPOU117
     27HSECOND))                                                    INPOU118
      GO TO 3475                                                     INPOU549
  349 GO TO (3474,3475,3475),II                                      INPOU550
C     ---------- DISPLAY CONVERTED TIME-TABLE VALUES
 3474 WRITE(KOUT,536) TIH(I),II,THE(I),TQR(I),TCM(I),TPI(I),TBRP(I)  INPOU551
      GO TO 3476                                                     INPOU552
```

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 3475 WRITE(KOUT,536) TTH(I),II,THE(I),TQR(I)                          INPOU553
 3476 CONTINUE                                                         INPOU554
C
C     END TIME-TABLE PROCESSING
C
C     ---------- CONDUCTIVITY TABLES FOR GAPS (UP TO FOUR)
C    NNGC1,GC2,NGC3,NGC4, = NUMBER OF TABULAR VALUES
C    TCONI = TEMPERATURE VALUES OF ITH TABLE
C    CONDI = CONDUCTIVITY VALUES OF ITH TABLE CORRESPONDING TO TCONI
C
      IF (ICOND.EQ.0) GO TO 120
      IF (ICOND.GT.4) GO TO 120
      READ (5,587) NGC1
      READ (5,588) (TCON1(I),COND1(I),I=1,NGC1)
      J=1
      WRITE(6,589) J,(TCON1(I),COND1(I),I=1,NGC1)
      IF (ICOND.EQ.1) GO TO 120
      READ (5,587) NGC2
      READ (5,588) (TCON2(I),COND2(I),I=1,NGC2)
      J=2
      WRITE(6,589) J,(TCON2(I),COND2(I),I=1,NGC2)
      IF (ICOND.EQ.2) GO TO 120
      READ (5,587) NGC3
      READ (5,588) (TCON3(I),COND3(I),I=1,NGC3)
      J=3
      WRITE(6,589) J,(TCON3(I),COND3(I),I=1,NGC3)
      IF (ICOND.EQ.3) GO TO 120
      READ (5,587) NGC4
      READ (5,588) (TCON4(I),COND4(I),I=1,NGC4)
      J=4
      WRITE(6,589) J,(TCON4(I),COND4(I),I=1,NGC4)
  120 CONTINUE
C
      IF (BRP.LT.0.0) WRITE(6,539)
  539 FORMAT(1H /9X,43HCH/CHO FROM PUTZ AND BARTLETTE CORRELATION    )
      IF (BRP.GE.0.0) WRITE(6,537)
  537 FORMAT (1H /9X,69HCH/CHO = PHI/(EXP(PHI)-1.) WHERE PHI = 2.*BRP*M INPOU103
     1DOT/CHO. BRP IN TABLE)                                            INPOU104
      IF(IEROS.NE.0) WRITE(6,583)
  583 FORMAT(50H   LUNDELL & DICKEY MECHANICAL EROSION CORRELATION     )
      IF(ISR.NE.0) WRITE(6,584)
  584 FORMAT(50H   ZERO SURFACE RECESSION OPTION IN EFFECT             )
      CALL LCOUNT(-1,LCF,NPG)
      IF (NC.GT.1) GO TO 743
      DO 3731 I=1,NTH
 3731 TPI(I)=ALOG(AMAX1(TPI(I),.000001))                               INPOU557
C
C     SURFACE CHEMISTRY DATA LEAD LINE
C
C     ---------- READ DATA FOR SURFACE EQUILIBRIUM TABLE               INPOU560
C     CMHS = CM/CH RATIO
C     VFZ = OPTION 1 VIEW FACTOR
C     BREX = EXPONENT USED TO ADJUST INPUT CONVECTIVE TRANSFER
C            COEFFICIENT (ROUCH) FOR RADIUS CHANGE DUE TO ABLATIVE
C     NR = ONE PUNCH CALLS FOR RADIUS RATIO CORRECTION PER ABOVE
C     NST = BLANK
C     NBPF = FLAG TO READ B PRIMEF IN "NEW FORMAT" SURFACE CHEM. TABLE
C     NFIS = FLAG TO INVOKE "FISSURE MODEL"
C     SWELL = CHAR SWELLS PROPORTIONAL TO CONSTANT K IN FOLLOWING
C              SWELL = K(ORIG SURF - SWELL)
```

```
C
      READ(INPUT,5796) CMHS,VFZ,BREX,NR,NST,NBPF,NFIS,SWELL                INPOU561
 5796 FORMAT(2F10.0,F9.0,I1,3(9X,I1),F10.0)                                INPOU141
      NFIS=NFIS+1                                                          INPOU562
      IF(NST.GT.0) GO TO 2901
      CMH = CMHS
      GO TO 2902                                                           INPOU565
 2901 IF (KNST.NE.777) GO TO 2909
      IF (CMH.NE.CMHS) GO TO 2907
      WRITE(KOUT,2906)
 2906 FORMAT(//10X50HSURFACE TABLES ARE THE SAME AS IN PREVIOUS PROBLEM)INPOU570
      CALL LCOUNT(3,LCT,NPG)
      GO TO 2912                                                           INPOU571
 2907 WRITE(KOUT,2908)                                                     INPOU572
 2908 FORMAT(//10X,72HPREVIOUS SURFACE TABLES CALLED FOR BUT CM/CH RATIO INPOU573
     1 HAS CHANGED, QUIT JOB//)                                            INPOU574
      STOP                                                                 INPOU575
 2909 WRITE(KOUT,2910)                                                     INPOU576
 2910 FORMAT(//10X,70HPREVIOUS SURFACE TABLES CALLED FOR BUT THIS IS FIR INPOU577
     1ST PROBLEM, QUIT JOB//)                                              INPOU578
      STOP                                                                 INPOU579
 2902 KNST=777                                                             INPOU580
 2912 IF (NR.GT.0) NR=1
      IF (NST.LE.0) GO TO 3285
      IF (NSEN) 2813,2861,2813
C
C     WLS = SAVED TEST VALUE OF WLQ
C     IP,IPN=PRESSURE INDEX
C     I,IN,J=UTILITY INDEX
C     NSEN=NUMBER OF ENTRIES IN CURRENT EDGE TABLE
C
 3285 WLS = -1
      NSEN=-1                                                              INPOU590
      IP=1                                                                 INPOU591
      IPN=1                                                                INPOU592
      I=1                                                                  INPOU593
      IN=1                                                                 INPOU594
C
C     PROCESS SURFACE THERMOCHEMISTRY TABLES
C
      J=0                                                                  INPOU595
 2800 J=J+1                                                                INPOU596
      IF (NBPF.NE.0) GO TO 28001
C     ---------- READ STANDARD SURFACE THERMOCHEMISTRY TABLES
C     USE EDGE TABLES WHEN CM/CH.NE.1.0
C              EDGE ENTHALPY TABLE          SURFACE THERMOCHEMISTRY
C     PSV   = PRESSURE                    |  PRESSURE
C     DMS   =   ---                       |  B PRIME GAS
C     TLMC  =   ---                       |  B PRIME CHAR
C     TTS   = TEMPERATURE                 |  SURFACE TEMPERATURE
C     WLQ   = UNEQUAL DIFFUSION EXPONENT  |  UNEQU. DIFF. EXP.
C     TCHEM= SUMMATION OF ZIE*HI**TW      |  SUMMATION OF ZIW*HI**TW
C     TSEN  = ENTHALPY OF EDGE GASES      |  ENTHALPY OF WALL GASES
C     JNG   = FLAG                        |  FLAG
C     TSURF= UNUSED ALPHANUMERIC          |  SURFACE SPECIES NAME
C
C     I = PYROLYSIS GAS RATE
C     J = CHAR RATE
C     K = PRESSURE
C
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      READ(INCH,5791) PSV,DMS,TLMC(J,I,IP),TTS(J,I,IP),WLQ,TCHEM(J,I,IP) INPOU598
     1,TSEN(J),JNG,TSURF(J)                                              INPOU599
 5791 FORMAT (3F8.5,F9.4,F5.3,2F9.3,I2,A6)                               INPOU130
      TBPF(J,I,IP)=0.                                                    INPOU600
      GO TO 28002                                                        INPOU601
C     ---------- READ "NEW FORMAT" URFACE THERMOCHEMISTRY TABLES
C     TBPF = B BRIME FAIL
28001 READ(INCH,5788)PSV,DMS,TLMC(J,I,IP),TTS(J,I,IP),WLQ,TCHEM(J,I,IP)  INPOU602
     1,TSEN(J),JNG,TSURF(J),TBPF(J,I,IP)                                 INPOU603
 5788 FORMAT(3F8.5,F9.4,F5.3,2F9.3,I2,2X,A4,4X,E10.3)                    INPOU605
28002 IF (JNG.LE.0) TSURF(J) = BLANK
      IF(TTS(J,I,IP)) 2803,2832,2801                                     INPOU609
C     ---------- CONVERT TO DEGREES FAHRENHEIT
 2801 TTS(J,I,IP)=TTS(J,I,IP)*1.8                                        INPOU610
      TCHEM(J,I,IP)=TCHEM(J,I,IP)*1.8                                    INPOU611
      TSEN(J)=TSEN(J)*1.8                                                INPOU612
C
      GO TO 2805                                                         INPOU613
 2803 TTS(J,I,IP)=-TTS(J,I,IP)                                           INPOU614
 2805 IF (WLS.LT.0.0) GO TO 2809
      IX=4
      IF(WLS-WLQ) 2824,2811,2824                                         INPOU617
 2809 WLS=WLQ                                                            INPOU618
 2811 IF (NSEN.GE.0) GO TO 2828
      IF (JNG.LT.0) GO TO 2800
C     ( NSEN = NUMBER OF ENTRIES IN CHEMISTRY TABLES )
      NSEN=J-1
      ISEN(IP)=NSEN                                                      INPOU622
      IF (NSEN.LE.1) GO TO 2820
        DO 2806 L=1,NSEN
        TTSEN(L,IP)=TTS(L,1,IP)                                          INPOU625
        TZSEN(L,IP)=TCHEM(L,1,IP)                                        INPOU626
 2806   THSEN(L,IP)=TSEN(L)                                              INPOU627
      CALL SLOPQ(NSEN,TTSEN(1,IP),THSEN(1,IP),TCPSEN(1,IP))              INPOU628
      CALL SLOPQ(NSEN,TTSEN(1,IP),TZSEN(1,IP),TCZSEN(1,IP))              INPOU629
      LLL=(NSEN-1)/3+1                                                   INPOU630
      IF (IP.NE.1) GO TO 28137
 2813 CALL LCOUNT(11+2*NR,LCT,NPG)
      WRITE (KOUT,538)                                                   INPOU633
      WRITE (KOUT,5797) CMH,WLQ,VFZ                                      INPOU634
 5797 FORMAT(//6X,45HRATIO OF MASS TO HEAT TRANSFER COEFFICIENTS =,F6.3/INPOU142
     1 6X,28HUNEQUAL DIFFUSION EXPONENT =,F6.3/6X,29HNOMINAL SURFACE VIEINPOU143
     2W FACTOR =,F6.3,11H (OPTION 1))                                    INPOU144
      IF (NFIS.EQ.1) GO TO 28130
      WRITE(KOUT,28132)
      GO TO 28133                                                        INPOU639
C
28130 WRITE(KOUT,28612)                                                  INPOU640
28133 CONTINUE                                                           INPOU641
      IF (NR.LE.0) GO TO 2818
      WRITE (KOUT,5799) BREX
 5799 FORMAT (6X,66HHEAT TRANSFER COEFFICIENT MULTIPLIED BY (R INITIAL/RINPOU147
     1 CURRENT)**EX,/8X,10HWHERE EX =  ,F8.5 )
      GO TO 2815                                                         INPOU644
C
 2818 WRITE (KOUT,5790)                                                  INPOU645
 2815 IF (SWELL.NE.0.0) GO TO 28134
      WRITE(KOUT,28136)
      GO TO 28137                                                        INPOU649
C
```

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28134 WRITE(KOUT,28138) SWEIT                                                  INPOU650
28137 IF (NST.GT.0) GO TO 743
      CALL LCOUNT(LLL+6,LCT,NPG)
      WRITE(KOUT,5792)PSV                                                      INPOU654
 5792 FORMAT(//6X,3HP =,F9.4,4H ATM//6X,3(25HTEMPERATURE  EDGE ENTH    )/INPOU131
     16X,3(25H  (DEG R)     AT T-WALL    ))                                   INPOU132
      DO 2819 LL=1,LLL                                                         INPOU655
 2819 WRITE(KOUT,5798) (TTSEN(L,IP),THSEN(L,IP),L=LL,NSEN,LLL)                 INPOU656
 5798 FORMAT                              (6X,F9.2,4X,F9.2,3X,F9.2,4X,F9.INPOU145
     12,3X,F9.2,4X,F9.2)                                                       INPOU146
      GO TO 2862                                                               INPOU657
C
 2820 NSEN=0                                                                   INPOU658
      IX=3                                                                     INPOU659
      IF (CMH.NE.1.0) GO TO 2824
      IX=2
      IF (WLQ.EQ.0.0) GO TO 2826
 2824 WRITE (KOUT,5793) IX
 5793 FORMAT (//6X,37HBAD SURFACE EQUILIBRIUM TABLE OF TYPE,I2)                INPOU133
      STOP                                                                     INPOU664
C
 2826 IF(IP-1) 2862,2861,2862                                                  INPOU665
 2828 IF (TTS(J,I,IP).EQ.0.0) GO TO 2832
      IF (PSV.NE.TPR(IP)) GO TO 2832
      IF(DMS-TMG(I,IP)) 2834,2800,2834
 2832 IPN=IP+1                                                                 INPOU669
      NMG(IP)=I                                                                INPOU670
      NGS = I
      IN=0                                                                     INPOU671
      NSEN=-NSEN                                                               INPOU672
 2834 IN=IN+1                                                                  INPOU673
      NHI(I,IP)=J-1                                                            INPOU674
      NMC=J-1                                                                  INPOU675
      CALL ORDERD(NMC,TLMC(1,I,IP),IZ)                                         INPOU676
      IF (NBPF.LE.0) GO TO 3852
      CALL SEQUA5(NMC,IZ,TTS(1,I,IP),TCHEM(1,I,IP),TSEN(1),TSURF(1),TBPF INPOU678
     1(1,I,IP))                                                                INPOU679
      GO TO 4853                                                               INPOU680
C
 3852 CONTINUE                                                                 INPOU681
      CALL SEQUA(NMC,IZ,TTS(1,I,IP),TCHEM(1,I,IP),TSEN(1),TSURF(1))            INPOU682
 4853 CONTINUE                                                                 INPOU683
      IX=0                                                                     INPOU684
      IG=1                                                                     INPOU685
      BPG=TMG(I,IP)                                                            INPOU686
      NLO(I,IP)=1                                                              INPOU687
      NHI(I,IP)=1                                                              INPOU688
C
C     FIRST STEP OF CALCULATING QCHEM/RUCH:
C     TCHEM = (B'G*HG + B'C*HC - B'C*HW) - (ZIE - ZIW)HI**TW
C
      DO 2852 K=1,NMC                                                          INPOU689
      BP=BPG+TLMC(K,I,IP)                                                      INPOU690
      IF (NFIS.EQ.1) GO TO 28340
      HGA=TSEN(K)
      GO TO 28342                                                              INPOU693
28340 CONTINUE                                                                 INPOU694
      CALL LOOK(2,TTS(K,I,IP),TT1,THG,0,0,0,HGA,CT1,1)                         INPOU695
      HGA=HGA+DELHG                                                            INPOU696
28342 CALL LOOK(4,TTS(K,I,IP),TT2(1,2),THZ(1,2),0,0,0,HCH,CT2,1)
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      HCH=HCH+DH2                                                        INPOU699
      IF (NSEN.NE.0) GO TO 2838
      NE=TCHEM(K,I,IP)
C     ---------- SIMPLIFIED SURFACE ENERGY BALANCE
C     USE FOR EQUAL DIFFUSION COEFFICIENT CASES AND WHEN CM/CH=1.0
C     TCHEM = B'G*HG + B'C*HC - B'*HW
C
      TCHEM(K,I,IP)=BPG*HGA+TLMC(K,I,IP)*HCH-BP*TSEN(K)                  INPOU702
      GO TO 2840                                                         INPOU703
 2838 CALL OGLE(1,TTS(K,I,IP),HZ,ISEN(IP),TTSEN(1,IP),TZSEN(1,IP),TCZSENINPOU704
     1(1,IP))                                                            INPOU705
      CALL OGLE(1,TTS(K,I,IP),HE,ISEN(IP),TTSEN(1,IP),THSEN(1,IP),TCPSENINPOU706
     1(1,IP))                                                            INPOU707
C     ---------- COMPLETE SURFACE ENERGY BALANCE
C     USE FOR UNEQUAL DIFFUSION COEFFICIENT CASES
C     TCHEM = B'G*HG + B'C*HC - B'*HEW + ZIE*HI**TW - ZIW*HI**TW
C
      TCHEM(K,I,IP)=BPG*HGA+TLMC(K,I,IP)*HCH-BP*TSEN(K)+HZ-TCHEM(K,I,IP)INPOU708
 2840 TSEN(K)=HE                                                         INPOU709
      IF (TSURF(K).NE.BLANK) GO TO 2844
      NLO(I,IP)=K+1
      IF(IG+IX-1) 2846,2846,2824                                         INPOU712
 2844 IX=1                                                               INPOU713
 2846 IF (K.LE.IG) GO TO 2852
      IF(TTS(K,I,IP).GT.TTS(K-1,I,IP)) GO TO 2851
      IG=NMC
      GO TO 2852                                                         INPOU717
 2851 KHI(I,IP)=K                                                        INPOU718
 2852 CONTINUE                                                           INPOU719
      LLL=(NMC-1)/2+1                                                    INPOU720
      CALL LCOUNT(LLL+6,LCT,NPG)
C     ---------- DISPLAY CHEMISTRY TABLES
      WRITE(KOUT,5795)TMG(I,IP),TPR(IP),((TTS(L,I,IP),TLMC(L,I,IP),TCHEMINPOU722
     1(L,I,IP),TSEN(L) ,L=LL,NMC,LLL),LL=1,LLL)                          IN
C
C (1/30/87) BELOW FORMAT CHANGED TO EXPAND CHEM.PROD. COLUMNS.
C
 5795 FORMAT(//6X,14HM-DOT-GAS/CM =,F7.4,8X,10HPRESSURE =,F11.6,4H ATM//
     16X,2(5H TEMP,5X,2HM-DOT-   CHEM.PROD  H WALL ,3X)/5X,              INPOU138
     22(38H (DEG R)  CHAR/CM    (BTU/LB) (BTU/LB),2X),/(5X,F8.2,2X,
     3  F7.4,1X,F11.2,1X, F8.1,2X,F8.2,1X,F8.4,1X,F11.2,1X,F8.1))
C
C    FINISH QCHEM/RUCH CALCULATION
C    (TCHEM' = CM/CH * TCHEM - HW)
C
        DO 2856 K=1,NMC                                                  INPOU724
        TCHEM(K,I,IP)=CMH*TCHEM(K,I,IP)-TSEN(K)                          INPOU725
        IF (K.LT.NLO(I,IP)) GO TO 2856
C     TAKE NATURAL LOG OF B'C
        TLMC(K,I,IP)=ALOG(AMAX1(TLMC(K,I,IP),.00001))
        IF (NBPF.LE.0) GO TO 2856
C     TAKE NATURAL LOG OF B'FAIL
        TBPF(K,I,IP)=ALOG(AMAX1(TBPF(K,I,IP),1.E-12))
 2856   CONTINUE                                                         INPOU730
      IF(TTS(J,I,IP)) 2862,2870,2862                                     INPOU741
C     ---------- WRITE OPTIONS
 2861 CALL LCOUNT(10+2*NR,LCT,NPG)
      WRITE (KOUT,538)                                                   INPOU743
      WRITE (KOUT,5794) VEV                                              INPOU744
 5794 FORMAT (//6X,74HEQUAL MASS AND HEAT TRANSFER COEFFICIENTS AND EQUAINPOU134
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     1L DIFFUSION COEFFICIENTS/6X,29HNOMINAL SURFACE VIEW FACTOR =,      INPOU135
     2F6.3)                                                             INPOU136
       IF (NFIS.EQ.1) GO TO 28610
       WRITE(KOUT,28132)
       GO TO 28613                                                      INPOU747
28610  WRITE(KOUT,28612)                                                INPOU748
28613  IF (NR.LE.0) GO TO 2863
       WRITE(KOUT,5799) BREX
       GO TO 2715                                                       INPOU753
 2863  WRITE (KOUT,5790)                                                INPOU754
 2715  IF (SWELL.NE.0.0) GO TO 2734
       WRITE(KOUT,28136)
       GO TO 2737                                                       INPOU757
 2734  WRITE(KOUT,28138) SWELL                                          INPOU758
C      ---------- OPTION TO REUSE PREVIOUS CHEMISTRY TABLES
 2737  IF (NST.GT.0) GO TO 743
 2862  TPR(IPN)=PSV                                                     INPOU760
       TMG(IN,IPN)=DMS                                                  INPOU761
       TLMC(1,IN,IPN)=TLMC(J,I,IP)                                      INPOU762
       TBPF(1,IN,IPN)=TBPF(J,I,IP)                                      INPOU763
       TTS (1,IN,IPN)=TTS (J,I,IP)                                      INPOU764
       TCHEM(1,IN,IPN)=TCHEM(J,I,IP)                                    INPOU765
       TSURF(1)=TSURF(J)                                                INPOU766
       TSEN(1)=TSEN(J)                                                  INPOU767
       J=1                                                              INPOU768
       I=IN                                                             INPOU769
C      (IP = PRESSURE INDEX )
       IP=IPN                                                           INPOU770
       GO TO 2800                                                       INPOU771
C
C      END LOOP TO PROCESS SURFACE CHEMISTRY DATA
C
 2870  NPR=IP                                                           INPOU772
       IR(12)=1                                                         INPOU773
       ILO(12)=1                                                        INPOU774
       IHI(12)=1                                                        INPOU775
C      ---------- TAKE NATURAL LOGARITHMS OF TABLE PRESSURES
         DO 2872 I=1,IP                                                 INPOU776
 2872    TPR(I)=ALOG(TPR(I))                                            INPOU777
       IR(13)=1                                                         INPOU778
       IHI(13)=NPR                                                      INPOU779
       ILO(13)=1                                                        INPOU780
  743  CALL DIKI(BA,BB,BC,TSEN,TL,TH,0,JTBL)
C
C ----- TO ACTIVATE SPECIAL HUNTER SUBROUTINE MERGER PROCEDURE BY CCC.
C      (12-28-87)
C      ----- JTBL MUST EQUAL 0 OR 1 TO READ IN VALUES BELOW -----
C     -IBLOPT = 0; NO CORRECTION ON QRAD DUE TO BLOWING EFFECTS-----
C     -IBLOPT = 1; CORRECT SURF. RAD'N H.T. USING AIR ABLATION SPECIES-
C     -IBLOPT = 2; CORRECT SURF. RAD'N H.T. USING CARBON ABLATION SPECIES-
C      IOPTN = 0; NO MERGING EVOKED. JTBL CAN BE 0 OR 1.
C      IOPTN = 1; USE A DIKI-TO-TABLES TRANSITION WALL TEMPERATURE;
C                 TCRIT REQUIRED.
C      IOPTN = 2; USE THE WALL TEMPERATURE AT A SPECIFIED BPRIME;
C                 BPCRIT REQUIRED.
C      IOPTN = 3; MERGE USING SLOPE SEARCH METHOD.
C      TCRIT = TEMPERATURE TRANSITION CRITERIA.
C      BPCRIT = FIND TEMPERATURE AT B' CRITERIA FOR TRANSITION.
C      IMSG = SWITCH TO PRINT MESSAGES;
C           = 0; DO NOT PRINT MESSAGES;
```

```
C           = 1; PRINT 'MERGER' MESSAGES (TIME,ITERATION,MERGE FACTOR);
C           = 2; PRINT 'MERGER' MESSAGES & MERGE2 OR MERGE3 MESSAGES.
C      MITER = NUMBER OF ITERATIONS BETWEEN UPDATES OF MERGE FACTOR.
C      ----- USE BELOW ONLY IF IOPTN > 0
C      TABCN = 0.0; USE MODIFIED HUNTER EQN. TO FIND NON-ABLATION TEMP.
C            > 0.0; NON-ABLATING MATERIAL BELOW TABCN.
C
C
       READ(5,2000)IBLOPT,IOPTN,TCRIT,BPCRIT,IMSG,TABCN,MITER
       IF(IBLOPT.LE.0) WRITE(6,2040)
       IF(IBLOPT.EQ.1) WRITE(6,2020)
       IF(IBLOPT.GE.2) WRITE(6,2030)
       IF(IOPTN.GE.1.AND.JTBL.GE.0) GO TO 2420
          IOPTN=0
          WRITE(6,2300)
          RETURN
 2420  IF(IOPTN.EQ.1) WRITE(6,2100) TCRIT
       IF(IOPTN.EQ.2) WRITE(6,2200) BPCRIT
       IF(IOPTN.GE.3) WRITE(6,2500)
       IF(TABCN.LE.0.0) WRITE(6,2550)
       IF(TABCN.GT.0.0) WRITE(6,2650)TABCN
       WRITE(6,2600)MITER
C      WRITE(6,2700)IMSG
C
 2000 FORMAT(2I5,2F10.4,I5,F10.4,I5)
 2040 FORMAT(//,' NO BLOWING EFFECT ON SURFACE RADIATIVE HEAT TRANSFER.'
     1 ,/)
 2020 FORMAT(//,' BLOWING EFFECT ON SURFACE RADIATIVE HEAT TRANSFER '
     1 ,'USING AIR ABLATION SPECIES.',/)
 2030 FORMAT(//,' BLOWING EFFECT ON SURFACE RADIATIVE HEAT TRANSFER '
     1 ,'USING CARBON ABLATION SPECIES.',/)
 2100 FORMAT(' DIKI-TO-TABLES MERGER TEMPERATURE',
     1' OF ',F10.5,' DEG R SELECTED.',/)
 2200 FORMAT(' SEARCH FOR MERGER TEMPERATURE AT BPRIME OF',F10.5,
     1' SELECTED.',/)
 2300 FORMAT(' DIKI-TO-TABLES MERGER OPTION NOT EVOKED.',/)
 2500 FORMAT(' SEARCH FOR MERGER TEMPERATURE BASED ON MINIMUM',
     1' SLOPE DIFFERENTIAL.',/)
 2550 FORMAT(' COMPUTE TEMPERATURE FOR NON-ABLATOR.',/)
 2650 FORMAT(' NON-ABLATOR TEMPERATURE OF ',F10.4,' DEG R SELECTED.',/)
 2600 FORMAT(' UPDATE MERGE FACTOR & NON-ABLATOR TEMP. EVERY',I5,
     1' ITERATIONS.',/)
C2700 FORMAT(' PRINT MESSAGES CODE = ',I3,/)
       RETURN
       END                                                    INPOU791
```

```
DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MAIN)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/19/88 019 14:41:17

C MAINLINE DUMMY ROUTINE WHICH DRIVES CBM AND INPOUT SUBROUTINES        MAIN   1
     1 CALL INPOUT                                                      MAIN   2
       CALL CBM                                                         MAIN   3
       GO TO 1                                                          MAIN   4
       END                                                              MAIN   5
C
C BLOCK DATA INITIALIZES COMMON VARIABLES TO ZERO.  DIMENSION OF X AND
C Y BELOW MUST BE INCREMENTED BY ABOUT 20 FOR EACH OF THEIR VARIABLES
C WHOSE DIMENSION HAS BEEN INCREASED.
C
C (1/20/87) X,Y RANDOMLY DIMENSIONED TO 40000 TO ACCOMMODATE CHANGE
C  TO MULTIPLE SUBSCRIPTED ARRAYS.
C
C  (1/29/87)  INCREASE X AND Y TO ACCOMODATE EXPANDING ALL ARRAYS.
C
C
      BLOCK DATA
C     COMMON X(80000)
      COMMON/OTPT/Y(1500)
C     DATA X/80000*0.0/,Y/1500*0.0/
C ----- ATMOSPHERE PROPERTY SUBROUTINE DATA
      COMMON /ATMOT/ Z(22),TMB(22),R(21), PB(22),C1,C2,C3,
     1         C7,C8,ZM,RO,GM,GAM,RST,GO,PO,WO,GO1
      DATA Y/1500*0.0/
      DATA    Z/      0., 11019., 20063., 32162., 47350., 52429.,
     1    61591., 79994., 90000.,100000.,110000.,120000.,150000.,
     2   160000.,170000.,190000.,230000.,300000.,400000.,500000.,
     3   600000.,700000. /
     4      ,TMB/  288.15, 216.65, 216.65, 228.65, 270.65, 270.65,
     5    252.65, 180.65, 180.65, 210.65, 260.65, 360.65, 960.65,
     6   1110.65,1210.65,1350.65,1550.65,1830.65,2160.65,2420.65,
     7   2590.65,2700.65  /
      DATA   R /  -6.5, 0.0, 1.0, 2.8, 0.0,-2.0,-4.0, 0.0, 3.0, 5.0,
     9        10.0,20.0,15.0,10.0, 7.0, 5.0, 4.0, 3.3, 2.6, 1.7, 1.1 /
      DATA   PB/ 1.00000E+00,2.23361E-01,5.40328E-02,8.56663E-03,
     21.09455E-03,5.82289E-04,1.79718E-04,1.02410E-05,1.62230E-06,
     32.96810E-07,7.25820E-08,2.48870E-08,4.99550E-09,3.64600E-09,
     42.75610E-09,1.66320E-09,6.86940E-10,1.85920E-10,3.97770E-11,
     51.08140E-11,3.40513E-12,1.17620E-12 /,C8/3.28084514/
     6  ,C1/0.3048/,C2/1.00E+03/,C3/1 8/,GO1/32.174/,C7/1.00E-08/
     7  ,ZM/9.00E+05/,RO/6.375605E+06/,GM/3.9862216E+14/,GAM/1.4/
     8  ,RST/8.31432/,GO/9.80665/,PO/2.11622E+03/,WO/28.9644/
      END
```

```
DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MERGER)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/13/88 013 14:11:55

      SUBROUTINE MERGER(FACTOR,XTEMP)
C                                                                      CBM    2
C SUBROUTINE TO MERGE HUNTER CARBON OXIDATION MODEL WITH               CBM    3
C CMA SURFACE THERMOCHEMISTRY TABLES.  CONTINUITY BETWEEN THE          CBM    4
C TWO ABLATION CURVES IS FORCED AT THE INTERFACE TEMPERATURE BY
C APPLYING A MULTIPLIER TO THE HUNTER MASS LOSS PARAMETER.
C THIS IS USED BECAUSE THE MAXIMUM HUNTER MASS LOSS PARAMETER IS
C 0.1741 WHEREAS THE TABLE VALUES THAT WERE CALCULATED BY THE EST
C CODE HAS A MINIMUM VALUE OF ABOUT 0.1750.  (THE OXIDATION VALUES
C IN THE TABLES ARE FROM GE DATA.
C
C INPUT IS XTEMP AND OUTPUT IS FACTOR.
C
      COMMON KOUT,IEX,DEN,VR                                           CBM    5
      COMMON IHI(76),ILO(76),IR(76),TT2(60,20),TCP(60,20),TKP(60,20),THZCBM    6
     1(60,20),TEP(60,20),TTH(120),THE(120),TQR(120),TCM(120),TT1(60)   INPOU  4
     2,THG(60),DH12(4),RECORD(108),SO(40),RHO(20),TEPBF(60,20)
      COMMON MATL(101),DEL(101),TA(101),H(101),RC(101),RA(101),
     1AREA(101),EMA(101),RAV(101),LGAP(101),QGEN(101),GAP(101)
      COMMON ROA(1000),ROB(1000),ROC(1000)                             CBM   12
      COMMON TPR(20),NMG(20),
     C                    TMG(5,20),NLO(5,20),NHI(5,20),KHI(5,20),
     1 TTSEN(30,20),THSEN(30,20),TCPSEN(30,20),TLMC(30,5,20),ISEN(20),
     2 TPI(120),  TTS(30,5,20),TCHEM(30,5,20),VFZ,CMH,TBPF(30,5,20),
     3 NPR,NGS
      COMMON LCT,NPG,II,NBM,NUMN,NL,DELHG,DELM,RFT,RHORA,RHORB,RHORC,TRACBM   18
     1CA,TRACB,TRACC,RHOOA,RHOOB,RHOOC,EA,EB,EC,BA,BB,BC,PSIA,PSIB,PSIC,CBM   19
     2TRACM,PET,PETE,RSV,ETA,DTPR3,DTPR2,DTPRT,TPR3,TPR2,THZRO,THFIN,WT,CBM   20
     3TMWT,GAMA,OMG,NO,FJFH,FJFS,JF,JFHP,JFH,INPUT,     DTHIN,BRP,HCONV,CBM   21
     4EPSW,TRES,INCH,DTHB,NN,NI,NOI,CHCRI,PYCRI,TBRP(120),NR,
     5 TX(30,6),F1(30,6),F2(30,6),NCON,NBPF,NFIS,BREX,SWELL
      COMMON BBB(10,6),EE(10,6),FF(10,6),PSI(10,6),RHOO(10,6),         CB
     XRHOR(10,6),
     1ROCOM(50,3),DHC(10),DHV(10),RHOC(10),RHOV(10),P(10),PP(10),
     XTREF(10),
     2GA(10),OMGA(10),NFI(10),NLA(10),TT5(60,20),TENT(60,20),
     XT.8U(60,20),
     3TCBU(30,10),X(101),NDBU,NBM2,TRAC(10,6),NBUFT(10),KNST,IBUG,TBUG,
     4 TALT(120),TVEL(120),RRGAP(101),AGAP(101),ICOND,IEROS,ISR,
     5 NGC1,NGC2,NGC3,NGC4,TCON1(101),TCON2(101),TCON3(101),TCON4(101),
     6 COND1(101),COND2(101),COND3(101),COND4(101),
     7 THCONV(101),TEPSW(101),TTRES(101),TQ(101),TEPSD(101),IBF,TL,THD,
     8 JTBL,IDRD,RHOCI(201),DTDT(201),RA1,RA2,RA3
      COMMON/OTPT/CPE(6),EMO(201),DEP(20,10),CNC(101),CN(101),Y1(4),
     1 CNO(101),TO(20),RO(101),NISO(20),BR,CH,GS,SA,TB,TT,ASU,CMD,CMT,
     2 ITS,QRP,RAD,RAT(101),RSU,CMDM,CMMT,DCDT,DEDT,DIDT,DPDT,ITER,KSCT,
     3 PGPU,PRES,QRPT,RADT,SNET,DECOM,DEDTT,DSDTB,PGPUT,QCHEM,QCOND,
     4 QCONV,QLOSS,SDNET,       SUMQE,THPRT,TSAVE,VELFS,DECOMT,
     5 PRSATM,QCHEMT,QCONDT,QCONVT,QLOSST,KK,RR(101),DMDG(101),
     6 RON(101),ROT(101),DNCP(6),DROT(6),D1(4),FA,FB,FC,DTH,DTHC,DSI,
     7 DTA,GSM,COLD,GSMS,GSMT,GSM2T,DSDT,POLD,TH,AFTFS,DSDTT,
     8 TEMP,BF,LL,LU,HE,HW
C ----- NEW COMMON BLOCKS ADDED BY CCC (12/87) FOR MERGE ROUTINES
      COMMON/MERGE/VRM,VRP,IMG,IPR,I1,I3
      COMMON/OPTION/TCRIT,BPCRIT,TABCN,IOPTN,IMSG,MITER
C     EQUIVALENCE (DH1,DH12(1)),(DH2,DH12(2)),(TS,TA(1))
      DIMENSION Y2(48),D2(48)
```

```
C                                                                       CBM  106
C     ---------- INTERPOLATE ON VMR, GAS FLOW
C     IF(NGS.LE.1) GO TO 200
C     CALL LOOK(15,XTEMP,TTS(1,IMG+1,IPR),TLMC(1,IMG+1,IPR),0,0,0,Y2(2),
C    1 D2,1)
C     CALL LOOK(17,XTEMP,TTS(1,IMG+1,IPR+1),TLMC(1,IMG+1,IPR+1),0,0,0,
C    1 Y2(4),D2,1)
C     BPG=Y2(2)+VRP*(Y2(2)-Y2(4))
C     WRITE(6,500)IR(13),VRM,VRP
C 500 FORMAT(' ***** IR(13)=',I5,
C    1       '  VRM =',E12.5,'   VRP =',E12.5)
C
C     IF(NGS.LE.1) GO TO 550
C     BP=BP+VRM*(BPG-BP)
C ----- LOOK UP BPRIME & INTERPOLATE ON VRP (LN PRESSURE RATIO)
      IF(IMSG.GE.3) WRITE(6,100) BPCRIT
  100 FORMAT(' **MRG** BPCRIT (INPUT) = ',F12.5)
      IF(IOPTN.EQ.2) GO TO 550
  200 CALL LOOK(14,XTEMP,TTS(1,IMG,IPR),TLMC(1,IMG,IPR),0,0,0,Y2(3),
     1 D2,1)
      CALL LOOK(16,XTEMP,TTS(1,IMG,IPR+1),TLMC(1,IMG,IPR+1),0,0,0,Y2(3),
     1 D2,1)
      BPEST=Y2(3)+VRP*(Y2(5)-Y2(3))
      BPEST=EXP(BPEST)
  550 Y2(1)=XTEMP
      CALL DIKI(PRES,BPDIKI,CH,Y2,DUM1,DUM2,-1,JTBL)
      BPDIKI=EXP(BPDIKI)
      IF(IOPTN.EQ.2) BPEST=BPCRIT
      FACTOR=BPEST/BPDIKI
C
      IF(IMSG.EQ.2) WRITE(6,600)BPEST,BPDIKI,FACTOR
  600 FORMAT(
     1  ' **MRG** BPEST =',F12.5,
     1  '   BPDIKI =',F12.5,'   FACTOR =',F12.5)
C
      IF(IMSG.EQ.3) WRITE(6,650)IPR,IMG,Y2(3),Y2(5),BPEST,BPDIKI,FACTOR
  650 FORMAT(' **MRG** IPR =',I3,4X,'   IMG =',I3,'   Y2(3) =',E12.5,
     1       '  Y2(5) =',E12.5,
     1 /,' ***** BPEST =',F12.5,'   BPDIKI =',F12.5,
     1 ' FACTOR =',F12.5)
C
      RETURN
      END                                                               CBM 1202
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DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MERGE2)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/25/88 025 10:38:12

      SUBROUTINE MERGE2(XTEMP)
C                                                                      CBM    2
C BY C.C.C. (12/87)
C
C SUBROUTINE TO MERGE HUNTER CARBON OXIDATION MODEL WITH               CBM    3
C CMA SURFACE THERMOCHEMISTRY TABLES.  CONTINUITY BETWEEN THE          CBM    4
C TWO ABLATION CURVES IS FORCED AT THE INTERFACE TEMPERATURE BY
C APPLYING A MULTIPLIER TO THE HUNTER MASS LOSS PARAMETER.
C SEE MERGER SUBROUTINE.
C THIS IS USED BECAUSE THE MAXIMUM HUNTER MASS LOSS PARAMETER IS
C 0.1741 WHEREAS THE TABLE VALUES THAT WERE CALCULATED BY THE EST
C CODE HAS A MINIMUM VALUE OF ABOUT 0.1750.  (THE OXIDATION VALUES
C IN THE TABLES ARE FROM GE DATA).
C THE INTERFACE TEMPERATURE IS FOUND FROM THE CHEMISTRY TABLES FOR A
C GIVEN MASS LOSS PARAMETER, BPRIME.
C
C A VALUE OF XTEMP IS COMPUTED FOR A GIVEN BPCRIT (IN COMMON BLOCK).
C
      COMMON KOUT,IEX,DEN,VR                                           CBM    5
      COMMON IHI(76),ILO(76),IR(76),TT2(60,20),TCP(60,20),TKP(60,20),THZCBM    6
     1(60,20),TEP(60,20),TTH(120),THE(120),TQR(120),TCM(120),TT1(60)    INPOU  4
     2,THG(60),DH12(4),RECORD(108),SO(40),RHO(20),TEPBF(60,20)
      COMMON MATL(101),DEL(101),TA(101),H(101),RC(101),RA(101),
     1AREA(101),EMA(101),RAV(101),LGAP(101),QGEN(101),GAP(101)
      COMMON ROA(1000),ROB(1000),ROC(1000)                             CBM    12
      COMMON TPR(20),NMG(20),
     C                TMG(5,20),NLO(5,20),NHI(5,20),KHI(5,20),
     1 TTSEN(30,20),THSEN(30,20),TCPSEN(30,20),TLMC(30,5,20),ISEN(20),
     2 TPI(120),  TTS(30,5,20),TCHEM(30,5,20),VFZ,CMH,TBPF(30,5,20),
     3 NPR,NGS
      COMMON LCT,NPG,II,NBM,NUMN,NL,DELHG,DELM,RFT,RHORA,RHORB,RHORC,TRACBM    18
     1CA,TRACB,TRACC,RHOOA,RHOOB,RHOOC,EA,EB,EC,BA,BB,BC,PSIA,PSIB,PSIC,CBM    19
     2TRACM,PET,PETE,RSV,ETA,DTPR3,DTPR2,DTPRT,TPR3,TPR2,THZRO,THFIN,WT,CBM    20
     3TMWT,GAMA,OMG,NO,FJFH,FJFS,JF,JFHP,JFH,INPUT,     DTHIN,BRP,HCONV,CBM    21
     4EPSW,TRES,INCH,DTHB,NN,NI,NOI,CHCRI,PYCRI,TBRP(120),NR,
     5 TX(30,6),F1(30,6),F2(30,6),NCON,NBPF,NFIS,BREX,SWELL
      COMMON BBB(10,6),EE(10,6),FF(10,6),PSI(10,6),RHOO(10,6),         CB
     XRHOR(10,6),
     1ROCOM(50,3),DHC(10),DHV(10),RHOC(10),RHOV(10),P(10),PP(10),
     XTREF(10),
     2GA(10),OMGA(10),NFI(10),NLA(10),TT5(60,20),TENT(60,20),
     XTKBU(60,20),
     3TCBU(30,10),X(101),NDBU,NBM2,TRAC(10,6),NBUFT(10),KNST,IBUG,TBUG,
     4 TALT(120),TVEL(120),RRGAP(101),AGAP(101),ICOND,IEROS,ISR,
     5 NGC1,NGC2,NGC3,NGC4,TCON1(101),TCON2(101),TCON3(101),TCON4(101),
     6 COND1(101),COND2(101),COND3(101),COND4(101),
     7 THCONV(101),TEPSW(101),TTRES(101),TQ(101),TEPSD(101),IBF,TL,THD,
     8 JTBL,IDRD,RHOCI(201),DTDT(201),RA1,RA2,RA3
      COMMON/OTPT/CPE(6),EMO(201),DEP(20,10),CNC(101),CN(101),Y1(4),
     1 CNO(101),TO(20),RO(101),NISO(20),BR,CH,GS,SA,TB,TT,ASU,CMD,CMT,
     2 ITS,QRP,RAD,RAT(101),RSU,CMDM,CMMT,DCDT,DEDT,DIDT,DPDT,ITER,KSCT,
     3 PGPU,PRES,QRPT,RADT,SNET,DECOM,DEDTT,DSDTB,PGPUT,QCHEM,QCOND,
     4 QCONV,QLOSS,SDNET,      SUMQE,THPRT,TSAVE,VELFS,DECOMT,
     5 PRSATM,QCHEMT,QCONDT,QCONVT,QLOSST,KK,RR(101),DMDG(101),
     6 RON(101),ROT(101),DNCP(6),DROT(6),D1(4),FA,FB,FC,DTH,DTHC,DSI,
     7 DTA,GSM,COLD,GSMS,GSMT,GSM2T,DSDT,POLD,TH,AFTFS,DSDTT,
     8 TEMP,BF,LL,LU,HE,HW
```

```
C ----- COMMON BLOCKS CREATED BY CCC (12/87) FOR MERGE ROUTINES
      COMMON/MERGE/VRM,VRP,IMG,IPR,I1,I3
      COMMON/OPTION/TCRIT,BPCRIT,TABCN,IOPTN,IMSG,MITER
      DIMENSION Y2(48),D2(48)
C
      BPCRTL = ALOG(AMAX1(BPCRIT,1.0E-5))
C                                                                    CBM  106
C     ---------- INTERPOLATE ON VMR, GAS FLOW
C     IF(NGS.LE.1) GO TO 200
C 200 CALL LOOK(15,BP,TLMC(1,IMG+1,IPR),TTS(1,IMG+1,IPR),0,0,0,
C    1 Y2(2),D2,1)
C     CALL LOOK(17,BP,TLMC(1,IMG+1,IPR+1),TTS(1,IMG+1,IPR+1),0,0,0,
C    1 Y2(4),D2,1)
C     XTG=Y2(2)+VRP*(Y2(4)-Y2(2))
C
C ----- LOOK UP TEMP. CORRESPONDING TO BPCRITL AT TABLE IPR & IPR+1
  200 CALL LOOK(14,BPCRTL,TLMC(1,IMG,IPR),TTS(1,IMG,IPR),0,0,0
     1 ,Y2(3),D2,1)
      CALL LOOK(16,BPCRTL,TLMC(1,IMG,IPR+1),TTS(1,IMG,IPR+1),0,0,0
     1 ,Y2(5),D2,1)
C ----- TRANSITION TEMPERATURE IS INTERPOLATED BETWEEN PRESSURE TABLES
      XTEMP=Y2(3)+VRP*(Y2(5)-Y2(3))
C
C     IF(NGS.LE.1) GO TO 550
C     XTEMP=XTEMP+VRM*(STG-XTEMP)
C     WRITE(6,650)IPR,Y2(3),Y2(5),XTEMP
C 650 FORMAT(' ***** IPR =',I4,'   Y2(3) =',E12.5,
C    1 '   Y2(5) =',E12.5,
C    1 '   XTEMP =',E12.5)
C
C     IF(TSAVE.GT.XTEMP) RETURN
C
      IF(IMSG.GE.2) WRITE(6,100)BPCRIT,XTEMP,ITER
  100 FORMAT(' **MG2** TRANSITION TEMP. AT BPRIME OF ',F9.5,
     1' IS ',F10.4,' DEG R - ITER = ',I5)
      RETURN
      END                                                            CBM 1202
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DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MERGE3)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/25/88 025 10:38:14

      SUBROUTINE MERGE3(XTEMP)
C                                                                      CBM    2
C BY CCC (12/87)
C
C SUBROUTINE TO MERGE HUNTER CARBON OXIDATION MODEL WITH               CBM    3
C CMA SURFACE THERMOCHEMISTRY TABLES.  CONTINUITY BETWEEN THE          CBM    4
C TWO ABLATION CURVES IS FORCED AT THE INTERFACE TEMPERATURE BY
C APPLYING A MULTIPLIER TO THE HUNTER MASS LOSS PARAMETER.
C SEE MERGER SUBROUTINE.
C THIS IS USED BECAUSE THE MAXIMUM HUNTER MASS LOSS PARAMETER IS
C 0.1741 WHEREAS THE TABLE VALUES THAT WERE CALCULATED BY THE EST
C CODE HAS A MINIMUM VALUE OF ABOUT 0.1750.  (THE OXIDATION VALUES
C IN THE TABLES ARE FROM GE DATA).
C THE INTERFACE TEMPERATURE IS FOUND BY USING A SEARCH PROCEDURE THAT
C COMPARES THE DIFFERENCE IN SLOPES OF THE TABLES AND THE DIKI
C SUBROUTINE.  THE LN(BPRIME)'S MUST ALSO BE WITHIN ABS(1.0).
C THE SEARCH STARTS AT THE LOWEST ABLATION TEMPERATURE FROM THE
C TABLES AND MARCHES IN 500 DEG R INCREMENTS.  WHEN THE RANGE IS FOUND
C THE INCREMENT IS REDUCED TO 100 DEG R WITHIN THIS RANGE FOR A REFINED
C SEARCH.
C
C A VALUE OF XTEMP IS OUTPUT FOR A GIVEN BPCRIT.
C
C     BP1 = VALUE OF BPRIME FROM DIKI AT (TEMP1 - DDT)
C     BP2 = VALUE OF BPRIME FROM DIKI AT (TEMP1 + DDT)
C     BPDIFF = AVERAGE OF BP1 AND BP2
C     BPREST = BPRIME FROM CHEMISTRY TABLES
C     DCDTED = DIFFERENCE IN SLOPES BETWEEN TABLES AND DIKI ROUTINE
C     DCDTD = SLOPE FROM CURVE COMPUTED IN DIKI ROUTINE
C     DCDTL = DIFFERENCE IN SLOPES FROM PRIOR SEARCH ITERATION
C     DCDTT = SLOPE FROM CURVE IN TABLES
C     DDT = TEMPERATURE STEP SIZE FOR DIKI SLOPE COMPUTATION
C     DT1 = FIRST TEMPERATURE SEARCH STEP SIZE
C     DT2 = SECOND TEMPERATURE SEARCH STEP SIZE
C     DTEMP = CURRENT TEMPERATURE STEP SIZE, EITHER DT1 OR DT2
C     ICOUNT = SEARCH ITERATION COUNTER
C     IFIRST = FLAG TO INDICATE FIRST SEARCH POINT
C     LIMIT = MAXIMUM NUMBER OF ITERATIONS
C     TEMP1 = CURRENT TEMPERATURE AT WHICH VALUES ARE EVALUATED
C     TLAST = TEMP1 FROM PRIOR SEARCH ITERATION
C     TMAX = MAXIMUM TEMPERATURE IN ABLATION PART OF TABLES
C     Y2 = DUMMY ARRAY VARIABLE
C
C

      COMMON KOUT,IEX,DEN,VR                                           CBM    5
      COMMON IHI(76),ILO(76),IR(76),TT2(60,20),TCP(60,20),IKP(60,20),THZCBM    6
     1(60,20),TEP(60,20),TTH(120),THE(120),TQR(120),TCM(120),TT1(60)    INPOU  4
     2,THG(60),DH12(4),RECORD(108),SO(40),RHO(20),TEPBF(60,20)
      COMMON MATL(101),DEL(101),TA(101),H(101),RC(101),RA(101),
     1AREA(101),EMA(101),RAV(101),EGAP(101),QGEN(101),GAP(101)
      COMMON ROA(1000),ROB(1000),ROC(1000)                             CBM   12
      COMMON TPR(20),NMG(20),
     C                      TMG(5,20),NLO(5,20),NHI(5,20),KHI(5,20),
     1 TTSEN(30,20),THSEN(30,20),TCPSEN(30,20),TLMC(30,5,20),ISEN(20),
     2 TPI(120),  TTS(30,5,20),TCHEM(30,5,20),VFZ,CMH,TBPF(30,5,20),
     3 NPR,NGS
      COMMON LCT,NPG,II,NBM,NUMN,NL,DELHG,DELM,RFT,RHORA,RHORB,RHORC,TRACBM   18
```

```
     1CA,TRACB,TRACC,RHOOA,RHOOB,RHOOC,EA,EB,EC,BA,BB,BC,PSIA,PSIB,PSIC,CBM    19
     2TRACM,PET,PETE,RSV,ETA,DTPR3,DTPR2,DTPRT,TPR3,TPR2,THZRO,THFIN,WT,CBM   20
     3TMWT,GAMA,OMG,NO,FJFH,FJFS,JF,JFHP,JFH,INPUT,     DTHIN,BRP,HCONV,CBM   21
     4EPSW,TRES,INCH,DTHB,NN,NI,NOI,CHCRI,PYCRI,TBRP(120),NR,
     5 TX(30,6),F1(30,6),F2(30,6),NCON,NBPF,NFIS,BREX,SWELL
      COMMON BBB(10,6),EE(10,6),FF(10,6),PSI(10,6),RHOO(10,6),                 CB
     XRHOR(10,6),
     1ROCOM(50,3),DHC(10),DHV(10),RHOC(10),RHOV(10),P(10),PP(10),
     XTREF(10),
     2GA(10),OMGA(10),NFI(10),NLA(10),TT5(60,20),TENT(60,20),
     XTKBU(60,20),
     3TCBU(30,10),X(101),NDBU,NBM2,TRAC(10,6),NBUFT(10),KNST,IBUG,TBUG,
     4 TALT(120),TVEL(120),RRGAP(101),AGAP(101),ICOND,IEROS,ISR,
     5 NGC1,NGC2,NGC3,NGC4,TCON1(101),TCON2(101),TCON3(101),TCON4(101),
     6 COND1(101),COND2(101),COND3(101),COND4(101),
     7 THCONV(101),TEPSW(101),TTRES(101),TQ(101),TEPSD(101),IBF,TL,THD,
     8 JTBL,IDRD,RHOCI(201),DTDT(201),RA1,RA2,RA3
      COMMON/OTPT/CPE(6),EMO(201),DEP(20,10),CNC(101),CN(101),Y1(4),
     1 CNO(101),TO(20),RO(101),NISO(20),BR,CH,GS,SA,TB,TT,ASU,CMD,CMT,
     2 ITS,QRP,RAD,RAT(101),RSU,CMDM,CMMT,DCDT,DEDT,DIDT,DPDT,ITER,KSCT,
     3 PGPU,PRES,QRPT,RADT,SNET,DECOM,DEDTT,DSDTB,PGPUT,QCHEM,QCOND,
     4 QCONV,QLOSS,SDNET,       SUMQE,THPRT,TSAVE,VELFS,DECOMT,
     5 PRSATM,QCHEMT,QCONDT,QCONVT,QLOSST,KK,RR(101),DMDG(101),
     6 RON(101),ROT(101),DNCP(6),DROT(6),D1(4),FA,FB,FC,DTH,DTHC,DSI,
     7 DTA,GSM,COLD,GSMS,GSMT,GSM2T,DSDT,POLD,TH,AFTFS,DSDTT,
     8 TEMP,BF,LL,LU,HE,HW
C ----- COMMON BLOCKS ADDED BY CCC FOR MERGE ROUTINES.
      COMMON/MERGE/VRM,VRP,IMG,IPR,I1,I3
      COMMON/OPTION/TCRIT,BPCRIT,TABCN,IOPTN,IMSG,MITER
      DIMENSION Y2(48),D2(48)
C ----- INITIAL VALUES AND CONSTANTS
C
      DT1 = 500.0
      DT2 = 100.0
      DTEMP = DT1
      DDT = 10.0
      IFIRST = 1
      ICOUNT=0
      LIMIT=16
C
C ----- LOCATE LOW & HI TEMP. FROM TABLES TO BOUND SEARCH PROCEDURE
C
      TEMP1 = TTS(I1,IMG,IPR)+VRP*(TTS(I3,IMG,IPR+1)-TTS(I1,IMG,IPR))
      TMAX = TTS(NHI(IMG,IPR),IMG,IPR)+VRP*(TTS(NHI(IMG,IPR+1),IMG,
     1 IPR+1)-TTS(NHI(IMG,IPR),IMG,IPR))
C     WRITE(6,801)VRP,IPR,I1,I3,TTS(I1,IMG,IPR),TTS(I1,IMG,IPR+1),TEMP1
C 801 FORMAT(' **MG3** VRP,IPR,I1,I3,TTS(1,IMG,IPR),TTS(1,IMG,IPR+1),'
C    1',TEMP1 = ',/,' ***** ', E12.5,3I6,3E12.5)
      GO TO 150
C
  100 TLAST = TEMP1
      DCDTL = DCDTED
      TEMP1 = TEMP1 + DTEMP
      IF(TEMP1.GT.TMAX) GO TO 1100
C ----- COMPUTE SLOPE & LN(BPRIME) FROM TABLES AT TEMP1 (AND PRES)
  150 ICOUNT=ICOUNT+1
      CALL LOOK(14,TEMP1,TTS(1,IMG,IPR),TLMC(1,IMG,IPR),0,0,0,Y2(1),
     1  Y2(2),1)
      CALL LOOK(16,TEMP1,TTS(1,IMG,IPR+1),TLMC(1,IMG,IPR+1),0,0,0,
     1  Y2(3),Y2(4),1)
```

```
C     WRITE(6,802)TMAX,Y2(1),Y2(3),Y2(2),Y2(4)
C 802 FORMAT(' **MG3** TMAX,Y2(1),Y2(3),Y2(2),Y2(4) = ',5E12.5)
      BPREST=Y2(1)+VRP*(Y2(3)-Y2(1))
      DCDTT=Y2(2)+VRP*(Y2(4)-Y2(2))
C ----- COMPUTE SLOPE & LN(BPRIME) FROM DIKI SUBROUTINE AT TEMP1
      Y2(1) = TEMP1 - DDT
      CALL DIKI (PRES,BP1,CH,Y2,DUM1,DUM2,-1,JTBL)
      Y2(1) = TEMP1 + DDT
      CALL DIKI (PRES,BP2,CH,Y2,DUM1,DUM2,-1,JTBL)
      BPDIKI=(BP1+BP2)/2.0
      DCDTD = (BP2-BP1)/(2.0*DDT)
C ----- COMPUTE DIFFERENCE BETWEEN DIKI & TABLE LN(BPRIME)'S & SLOPES
      BPDIFF=BPREST-BPDIKI
      DCDTED = DCDTT - DCDTD
      IF(IMSG.GE.3) WRITE(6,803)BPREST,BPDIKI,DCDTT,DCDTD
  803 FORMAT(' **MG3** BPREST,BPDIKI,DCDTT,DCDTD =
     1,/,' ***** ',5E12.5)
C ----- NEXT TEMPERATURE
      IF(IFIRST.NE.1) GO TO 200
      IFIRST = 0
      GO TO 100
C ----- COMPARE LAST AND CURRENT DIFFERENCE IN SLOPES
C ----- AND TEST FOR DIFFERENCE OF LN(BPRIME)'S LESS THAN 1.0
  200 CONTINUE
      IF(IMSG.GE.3) WRITE(6,800)TEMP1,TLAST,DCDTED,DCDTL,BPDIFF
  800 FORMAT(' **MG3** TEMP1,TLAST,DCDTED,DCDTL,BPDIFF = ',5E12.5)
      IF(ICOUNT.GE.LIMIT)           GO TO 600
      IF(BPDIFF.GE.1.0)             GO TO 100
      IF(DCDTL.LT.0.AND.DCDTED.LT.0) GO TO 100
      IF(DCDTL.GT.0.AND.DCDTED.GT.0) GO TO 600
      IF(DCDTL.LE.0.AND.DCDTED.GE.0) GO TO 400
C ----- INTERPOLATE XTEMP OR DO SECOND SEARCH WITH SMALLER DTEMP
  400 IF(DTEMP.EQ.DT1) GO TO 500
        XTEMP = TEMP1 - DCDTED/(DCDTED-DCDTL)*(TEMP1-TLAST)
        IF(TSAVE.GT.XTEMP) RETURN
        IF(IMSG.GE.2) WRITE(6,1000)XTEMP,ITER
        RETURN
C ----- REFINED TEMP. STEP USED WHEN FIRST RANGE IS LOCATED
  500 DTEMP = DT2
      TEMP1=TLAST+DTEMP
      GO TO 150
C --- EXIT IF ITERATIONS EXCEEDED OR IF DCDTED ALWAYS GREATER THAN ZERO
  600 XTEMP = TLAST
      WRITE(6,700)XTEMP
  700 FORMAT(' **MG3** WARNING ***** MERGE ROUTINE SEARCH PROCEDURE',
     1 ' REACHED ITERATION LIMIT.',/,' *****  (XTEMP = ',F10.4,' R).')
      WRITE(6,1000)XTEMP,ITER
 1000 FORMAT(' **MG3** TRANSITION TEMPERATURE FROM SEARCH ROUTINE IS'
     1 , F10.5,' DEG R - ITER = ',I5 )
      STOP
 1100 WRITE(6,1200)TMAX
      WRITE(6,1200)TMAX
      WRITE(6,1200)TMAX
 1200 FORMAT(' **MG3** LAST TEMPERATURE ENTRY OF TABLE REACHED, NO ',
     1'MERGE POINT FOUND.  TMAX = ',E12.5)
      STOP
      END                                                    CBM 1202
```

```
DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(OUTPT2)'                    VOL=SER=D8D080
DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)                  01/19/88 019 14:41:18

      SUBROUTINE OUTPT(JJJ)
C
C     CHANGES TO PROGRAM:
C     (1/16/87) SIZE OF TTH,THE,TQR,TCM,TBRP,TALT,TVEL,TPI
C               EXPANDED TO 120 ELEMENT ARRAYS
C     (1/19/87) SIZE OF TTSEN,THSEN,TCPSEN,TLMC,TTS,TCHEM,TBPF,
C               TPR,NMG,TMG,NLO,NHI,KHI,ISEN,
C               EXPANDED TO ACCOMMODATE 20 EST TABLES WITH 30
C               ENTRIES EACH
C
C     (1/29/87) ALL OTHER SUBSCRIPTED VARIABLE DIMENSIONS DOUBLED
C               AS RECOMMENDED BY L.L. PERINI.
C
C  ADDED WRITEOUT OF NODAL DEPTHS & TEMPS TO UNIT 8
      COMMON KOUT,IEX,DEN,VR                                          CBM    5
      COMMON IHI(76),ILO(76),IR(76),TT2(60,20),TCP(60,20),TKP(60,20),THZCBM    6
     1(60,20),TEP(60,20),TTH(120),THE(120),TQR(120),TCM(120),TT1(60)    INPOU  4
     2,THG(60),DH12(4),RECORD(108),SO(40),RHO(20),TEPBF(60,20)
      COMMON MATL(101),DEL(101),TA(101),H(101),RC(101),RA(101),
     1AREA(101),EMA(101),RAV(101),LGAP(101),QGEN(101),GAP(101)
      COMMON ROA(1000),ROB(1000),ROC(1000)                            CBM   12
      COMMON TPR(20),NMG(20),
     C                        TMG(5,20),NLO(5,20),NHI(5,20),KHI(5,20),
     1 TTSEN(30,20),THSEN(30,20),TCPSEN(30,20),TLMC(30,5,20),ISEN(20),
     2 TPI(120),  TTS(30,5,20),TCHEM(30,5,20),VFZ,CMH,TBPF(30,5,20),
     3 NPR,NGS
      COMMON LCT,NPG,II,NBM,NUMN,NL,DELHG,DELM,RFT,RHORA,RHORB,RHORC,TRACBM    18
     1CA,TRACB,TRACC,RHOOA,RHOOB,RHOOC,EA,EB,EC,BA,BB,BC,PSIA,PSIB,PSIC,CBM   19
     2TRACM,PET,PETE,RSV,ETA,DTPR3,DTPR2,DTPRT,TPR3,TPR2,THZRO,THFIN,WT,CBM   20
     3TMWT,GAMA,OMG,NO,FJFH,FJFS,JF,JFHP,JFH,INPUT,     DTHIN,BRP,HCONV,CBM   21
     4EPSW,TRES,INCH,DTHB,NN,NI,NOI,CHCRI,PYCRI,TBRP(120),NR,
     5 TX(30,6),F1(30,6),F2(30,6),NCON,NBPF,NFIS,BREX,SWELL
      COMMON BBB(10,6),EE(10,6),FF(10,6),PSI(10,6),RHOO(10,6),
     XRHOR(10,6),
     1ROCOM(50,3),DHC(10),DHV(10),RHOC(10),RHOV(10),P(10),PP(10),
     XTREF(10),
     2GA(10),OMGA(10),NFI(10),NLA(10),TT5(60,20),TENT(60,20),
     XTKBU(60,20),
     3TCBU(30,10),X(101),NDBU,NBM2,TRAC(10,6),NBUFT(10),KNST,IBUG,TBUG,
     4 TALT(120),TVEL(120),RRGAP(101),AGAP(101),ICOND,IEROS,ISR
      COMMON/OTPT/CPE(6),EMO(201),DEP(20,10),CNC(101),CN(101),Y1(4),
     1 CNO(101),TO(20),RO(101),NISO(20),BR,CH,GS,SA,TB,TT,ASU,CMD,CMT,
     2 ITS,QRP,RAD,RAT(101),RSU,CMDM,CMMT,DCDT,DEDT,DIDT,DPDT,ITER,KSCT,
     3 PGPU,PRES,QRPT,RADT,SNET,DECOM,DEDTT,DSDTB,PGPUT,QCHEM,QCOND,
     4 QCONV,QLOSS,SDNET,       SUMQE,THPRT,TSAVE,VELFS,DECOMT,
     5 PRSATM,QCHEMT,QCONDT,QCONVT,QLOSST,KK,RR(101),DMDG(101),
     6 RON(101),ROT(101),DNCP(6),DRQT(6),D1(4),FA,FB,FC,DTH,DTHC,DSI,
     7 DTA,GSM,COLD,GSMS,GSMT,GSM2T,DSDT,POLD,TH,AFTFS,DSDTT,
     A IEMP,BF,LL,LU,HE,HW
      COMMON/OPTION/TCRIT,BPCRIT,TABEN,IOPTN,IMSG,MITER,IBLOPT
      COMMON/BLOWIN/BLOW,BLOFAC
      EQUIVALENCE (DH1,DH12(1)),(DH2,DH12(2)),(TS,TA(1))
  554 FORMAT(1X,8F10.4/(20X,6F10.4))                                  CBM   103
 4102 FORMAT(72E14.7,10I10)
      DIDT = 12.0*DSDTB
      NDR=NBM-NL-1                                                    CBM   279
      NL1=(NUMN-NDR+1)/2                                              CBM   280
```

```
      K=NLI                                                              CBM  281
      BPRM = 0.0
      BPRMG=0.0
      IF ( ABS(CH).LT.1.0E-15) GO TO 4105
      BPRM=(GS  +CMD)/(CH*CMH)                                           CBM  288
      BPRMG=GS  /(CH*CMH)                                                CBM  289
      CALL LOOK(3,TS,TT2(1,1),THZ(1,1),0,0,0,TEMP,DUM,1)
C     ---------- TEMP = INTERPOLATED ENTHALPY OF MATERIAL
      HW = (BPRM*TEMP-QCHEM/CH)/(1.0+BPRM)
C
C    PRINT OUTPUT AT REQUESTED TIME
C
 4105 CALL LCOUNT(33+NLI,LCT,NPG)
C
      WRITE (KOUT,543)TH
  543 FORMAT( /6X28H- - - - - - - - - - - - - - - F9.4,37H SECONDS  - - -
     1- - - - - - - - - - - - )                                          CBM   53
C
      WRITE (KOUT,544)                                                   CBM  284
  544 FORMAT(6X,4HTIME,2X,4HSURF,2X,4HPROB,2X,7HSURFACE,5X,6HH WALL,     CBM   54
     14X,6HH EDGE,6X,10HHEAT COEFF,6X,6HCH/CHO/6X,4HSTEP,2X,4HITER,2X,4HCBM   55
     20PTN,2X,8HRAD (IN),3X,8H(BTU/LB),2X,8H(BTU/LB),3X,14H(LB/SQ FT-SECCBM   56
     3))                                                                 CBM   57
C
      WRITE (KOUT,545) ITER,ITS,II    ,RSU,HW,HE,CH,BR                   CBM  285
  545 FORMAT(6X,I4,2I6,F10.4,F11.2,F10.2,F14.6,5X,F8.5/1H )              CBM   58
C
      WRITE (KOUT,546)                                                   CBM  286
  546 FORMAT(33X,20H---ABLATION RATES---)                                CBM   59
C
      IF(IBLOPT.LE.0) GO TO 580
C     OUTPUT WHEN USING BLOWING OPTION OF QRAD
      WRITE (KOUT,570)                                                   CBM  287
  570 FORMAT('  B PRIME    B PRIME G  M DOT CHAR  M DOT ERS    ',
     1'M CHAR         M ERS       PERCENT      QRAD',/26X,
     1'(LB/SQ FT-SEC)          (LB/ORIG SQ FT)          ',
     2'  BLOWING  FRACTION')                                             CBM   62
C
      WRITE (KOUT,571) BPRM,BPRMG,CMD,CMDM,CMT,CMMT,BLOW,BLOFAC
  571 FORMAT(1X,F8.5,2X,F8.5,3X,F10.6,3(2X,F10.6),2X,F9.5,2X,F7.5,/1H )  CBM   63
      GO TO 585
C
  580 CONTINUE
      WRITE (KOUT,547)                                                   CBM  287
  547 FORMAT(8X,7HB PRIME,3X,9HB PRIME G,3X,10HM DOT CHAR,3X,9HM DOT ERS
     16X,6HM CHAR,7X,5HM ERS/34X,14H(LB/SQ FT-SEC),11X,15H(LB/ORIG SQ FT
     2))                                                                 CBM   62
C
      WRITE (KOUT,548) BPRM,BPRMG,CMD,CMDM,CMT,CMMT
  548 FORMAT(8X,F8.5,2X,F8.5,4(3X,F10.6)/1H )                            CBM   63
  585 CONTINUE
C
      WRITE (KOUT,5480) CHCRI,PYCRI                                      CBM  291
 5480 FORMAT(27X,32H---RECESSIONS/RECESSION RATES---/                    CBM   64
     133X,19H(IN)    /    (IN/SEC)/                                      CBM   65
     2  16X,7HSURFACE,16X,6HCHAR (,F4.2,1H),11X,11HPYROLYSIS (,F4.2,1H))CBM   66
C
      WRITE (KOUT,5481) SA,DIDT,CPE(1),DCDT,CPE(2),DPDT                  CBM  292
 5481 FORMAT(5X,3(4X,F10.7,1H/,F9.7)/1H )                                CBM   67
C
```

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      WRITE (KOUT,5482)                                                    CBM  293
 5482 FORMAT(27X,31H---SURFACE ENERGY FLUX TERMS---/25X,37HCURRENT RATESCBM   68
     1 (BTU/SQ FT SURFACE-SEC)/24X,38HAND INTEGRATED VALUES (BTU/ORIG SQCBM   69
     2 FT)/                                                               CBM  70
     3     13X,10HCONVECTED ,4X,10H RADIATED ,4X,10H RADIATED ,4X,10H CHECBM   71
     4MICAL ,4X,10HCONDUCTION/17X,2HIN,12X,2HIN,11X,3HOUT,8X,10HGENERATICBM   72
     5ON,7X,4HAWAY)                                                       CBM  73
C
      WRITE (KOUT,5483) QCONV,QRP,RAD,QCHEM,QCOND,QCONVT,QRPT,RADT,QCHEMCBM  294
     1T,QCONDT                                                            CBM  295
C     ----- 5483 EXPANDED FIELD FORMATS
 5483 FORMAT (6X,4HRATE,2X,5(E12.5,2X)/6X,5HTOTAL,1X,5(E12.5,2X)/1H )     CBM   74
C
      WRITE (KOUT,5484)                                                    CBM  296
 5484 FORMAT(30X,27H---INTERIOR ENERGY TERMS---/
     3       13X,9HPYROL GAS,7X,6HDECOMP,6X,10HCONVECTION,6X,7HSTORAGE, CBM   78
     47X,7HLOSS AT/14X,7HPICK UP,6X,10HABSORPTION,3X,11HWITH SOLIDS,5X, CBM   79
     58HIN SOLID,6X,9HREAR FACE)                                          CBM  80
C
      WRITE (KOUT,5485)PGPU,DECOM, TB,DEDT,QLOSS,PGPUT,DECOMT, TT,DEDTT,CBM  297
     1QLOSST                                                              CBM  298
 5485 FORMAT (6X,4HRATE,2X,5(E12.5,2X)/6X,5HTOTAL,1X,5(E12.5,2X)/1H )     CBM   81
C
      PRSATM = EXP(PRES)
C
      WRITE(6,584) SUMQE,PRSATM,VEL,FS,ALTFS
  584 FORMAT( 18H QERR(BTU/FT2)   =,F8.2,10H ,PT(ATM)=,F10.6 ,
     1       11H ,VEL(FPS)=,F8.1 ,10H ,ALT(FT)= ,F9.1)
C
      IF(NCON.LE.0) WRITE(6,549)
  549 FORMAT (6X8HNODE MAT3X4HTEMP3X7HDENSITY3X8HENTHALPY2X8HNODE MAT3X4CBM   82
     1HTEMP3X7HDENSITY3X8HENTHALPY/15X7H(DEG R)11H (LB/CU FT)9H (BTU/LB)CBM   83
     211X7H(DEG R)11H (LB/CU FT)9H (BTU/LB))                              CBM  84
C
      IF(NCON.GT.0) WRITE(6,5490)
 5490 FORMAT(6X,8HNODE MAT,3X,4HTEMP,3X,7HDENSITY,2X,9HCOND(BTU/,2X,8HNOCBM   85
     1DE MAT,3X,4HTEMP,3X,7HDENSITY,2X,9HCOND(BTU//15X,7H(DEG R),11H (LBCBM   86
     2/CU FT),9H FT SC F),11X,7H(DEG R),11H (LB/CU FT),9H FT SC F))       CBM  87
C
      WRITE(8,3001)TH,(RAV(I),TA(I),I=1,NUMN)
 3001 FORMAT(F10.5,50(F6.5,F5.0))
C
      IF(NOI.LE.0) GO TO 190
      CALL SLOPQ (NL,RA(1),TA(1),EMO(1))
      IF(NO.LE.0) GO TO 182
      CALL OGLE (NO,SO,TO(1),NL,RA(1),TA(1),EMO(1))
  182 IF(NI.LE.0) GO TO 189
        DO 186 I=1,NI
        TO(I) = PIF1(SO(I),RA,NL,TA)
  186   CONTINUE
  189 IF(NUMN.GE.NBM) CALL THERMS(NISO,TO,DEP,RR,CN,RAT)
      WRITE(KSCT,4102) TH,TS,(TO(I),I=1,20),
     1 ((DEP(I,J),I=1,10),J=1,5),(NISO(I),I=1,10)
      KK=KK+1                                                              CBM  325
  190 M = WT
      IF(NCON.LE.0) GO TO 3012
        DO 3009 I=1,NL
        IF(WT.LE.0.0) GO TO 3007
        CALL LOOK(31+M,X(I),TX(1,M),F1(1,M),F2(1,M),0.0,Y1,D1,2)
        CNO(I)=Y1(1)*CN(I)+Y1(2)*CNC(I)                                    CBM  332
```

```
        GO TO 3009                                                          CBM  333
3007    CNO(I)=X(I)*CN(I)+(1.0-X(I))*CNC(I)                                 CBM  334
3009    CONTINUE                                                            CBM  335
      IF(NDBU.LE.0) GO TO 3023
        DO 3030 I=1,NDBU
        LL=NFI(I)                                                           CBM  338
        LU=NLA(I)                                                           CBM  339
        L=NBUFT(I)                                                          CBM  340
          DO 3025 J=LL,LU                                                   CBM  341
          IF(L.LE.0) GO TO 3026
          CALL LOOK(31+L,X(J),TX(1,L),F1(1,L),F2(1,L),0,0,Y1,D1,2)          CBM  343
          CNO(J)=Y1(1)*CN(J)+Y1(2)*CNC(J)                                   CBM  344
          GO TO 3025                                                        CBM  345
3026      CNO(J)=X(J)*CN(J)+(1.0-X(J))*CNC(J)                               CBM  346
3025      CONTINUE                                                          CBM  347
3030    CONTINUE                                                            CBM  348
3023  IF(NUMN.LT.NBM2) GO TO 3012
        DO 3029 I=NBM2,NUMN
3029    CNO(I)=CN(I)                                                        CBM  351
3012  DO 3011 J=1,NLI
      L=J                                                                   CBM  354
      IF(L.LE.NL) GO TO 3002
      L=L+NDR
      K=NLI                                                                 CBM  357
      GO TO 3003                                                            CBM  358
3002  IF(L+NLI.GT.NL) K = NLI+NDR
3003  N=MINO(NUMN,K+L)
      IF(NCON.LE.0)WRITE(6,550)(I,MATL(I),TA(I),RO(I),H(I),I=L,N,K)
 550  FORMAT (5X2I4,F9.2,F10.3,2XF8.2,1X2I4,F9.2,F10.3,F10.2)               CBM   88
      IF(NCON.GT.0)WRITE(6,5500)(I,MATL(I),TA(I),RO(I),CNO(I),I=L,N,K)
5500  FORMAT(5X,2I4,F9.2,F10.3,2X,F8.6,1X,2I4,F9.2,F10.3,F10.6)             CBM   89
3011  CONTINUE                                                              CBM  366
      IF(SWELL.EQ.0.0) GO TO 3101
      SDNET=(1.+SWELL)*DIDT-SWELL*DCDT
C
      WRITE(6   ,590) SNET,SDNET
 590  FORMAT(/10X,48HSURFACE RECESSION AFTER SWELL (INCHES)          = F8CBM  370
     1.4/10X,48HSURFACE RECESSION RATE WITH SWELL (INCHES/SEC) =F8.4)   CBM  371
C
3101  IF(TH-THFIN.LT.-0.00001) GO TO 1151
      IF(NOI.LE.0) GO TO 1
      REWIND KSCT
      N=0                                                                   CBM  392
      CALL LCOUNT(-18,LCT,NPG)
C
      WRITE(KOUT,552)  NO,NI                                                CBM  394
 552  FORMAT(9X,67HOPTIONAL OUTPUT OF THERMOCOUPLE TEMPERATURES AND/OR ICBM   92
     1SOTHERM DEPTHS/24X,37HDEPTHS MEASURED FROM ORIGINAL SURFACE/24X,  CBM   93
     231HTEMPERATURES IN DEGREES RANKINE//6X,77HEACH OUTPUT BLOCK SHOWS CBM   94
     3THE TIME IN SECONDS, THE CURRENT SURFACE TEMPERATURE,/6X,20HTHE TECBM   95
     4MPERATURES OF ,I2,44H THERMOCOUPLES, AND THE DEPTHS IN INCHES OF ,CBM   96
     512,10H ISOTHERMS/6X,34HWITHIN THE MAIN ABLATING MATERIAL./)       CBM   97
C
      WRITE(KOUT,5521)                                                      CBM  395
5521  FORMAT(6X,           74HTHE FIRST BLOCK SHOWS A SAMPLE TIME AND SUCBM   98
     6RFACE TEMPERATURE, THE SPECIFIED/6X,73HDEPTHS OF THE THERMOCOUPLESCBM   99
     7 (IF ANY) AND THE ISOTHERM TEMPERATURES.   THE/6X,76HARRANGEMENT OCBM  100
     8F THIS BLOCK CORRESPONDS TO THE ARRANGEMENT OF THE OUTPUT DATA./) CBM  101
      WRITE(KOUT,554) TH,TS,(SO(I),I=1,NOI)                                 CBM  396
C
```

```
      WRITE (KOUT,553)                                                  CBM  397
  553 FORMAT (//6X,11HOUTPUT DATA//)                                    CBM  102
C
        DO 4 K=1,KK                                                     CBM  398
        READ (KSCT,4102) TH,TS,(TO(I),I=1,20),
     1  ((DEP(I,J),I=1,10),J=1,5),(NISO(I),I=1,10)
          DO 805 I=1,NI                                                 CBM  400
          IF (N.LT.NISO(I)) N=NISO(I)
  805     CONTINUE                                                      CBM  403
        CALL LCOUNT( 1 ,LCT,NPG)
    4   WRITE (KOUT,554) TH,TS, (TO(I), I=1,NCI)                        CBM  405
      IF(NUMN.LT.NBM) GO TO 1
      IF(NI*.LE.0) GO TO 1
      REWIND KSCT
      CALL LCOUNT(-7,LCT,NPG)
C
      WRITE(KOUT,560)                                                   CBM  410
  560 FORMAT(/6X66HTHE FOLLOWING BLOCK GIVES THE OUTPUT TIME AND UP TO FCBM  414
     1IVE LOCATIONS / 6X,55HOF THE INDICATED ISOTHERMS WITHIN THE BACKUPCBM  415
     2 MATERIALS.)                                                      CBM  416
C
      J=NO+1                                                            CBM  411
      WRITE(KOUT,7041) (SO(I),I=J,NOI)                                  CBM  412
 7041 FORMAT(//12X,9(2X,F10.4))                                         CBM  417
      WRITE(KOUT,7042)                                                  CBM  413
 7042 FORMAT(/)                                                         CBM  418
C
      DO 804 K=1,KK                                                     CBM  419
      READ (KSCT,4102) TH,TS,(TO(I),I=1,20),
     1 ((DEP(I,J),I=1,10),J=1,5),(NISO(I),I=1,10)
      DO 804 J=1,N                                                      CBM  421
      CALL LCOUNT( 1,LCT,NPG)
  804 WRITE(KOUT,554) TH,(DEP(I,J),I=1,NI)                              CBM  423
      GO TO 1                                                           CBM  424
 1151 IF(TH.LT.TPR2-0.00001) GO TO 154
      DTPRT=DTPR2
      DTPR2=DTPR3                                                       CBM  427
      TPR2=TPR3                                                         CBM  428
      TPR3=THFIN                                                        CBM  429
  154 IF(TH.GE.THPRT-0.00001) THPRT=AMIN1(THPRT+DTPRT,TPR2)
      RETURN
    1 JJJ = 1
      RETURN
      END
```

APPENDIX B

SURFACE ENERGY BALANCE EQUATION IN CMA

APPENDIX B

Surface Energy Balance Equation in CMA

$$\underbrace{\rho_e u_e C_H (H_r - h_w)}_{\substack{\text{Convective} \\ \text{heat transfer}}} + \underbrace{\rho_e u_e C_H \left[\left(\frac{C_M}{C_H} \right) (\beta_c' h_c + \beta_g' h_g - \beta' h_w) \right]}_{\substack{\text{Chemical energy} \\ \text{transfer}}} +$$

$$\underbrace{\alpha_w q_{\text{rad}}}_{\substack{\text{Radiative} \\ \text{heating}}} - \underbrace{F\sigma\epsilon_w T_w^4}_{\substack{\text{Radiation} \\ \text{loss}}} - \underbrace{q_{\text{cond}}}_{\substack{\text{Conduction} \\ \text{to wall}}} = 0 \quad ,$$

where

ρ_e = density at outer edge of boundary layer,
u_e = velocity of gases at edge of boundary layer,
C_H = Stanton number,
H_r = recover enthalpy,
C_M = mass transfer Stanton number,
β_c' = mass loss parameter of char (equals $\dot{m}_c / \rho_e u_e C_M$),
β_g' = mass loss parameter of pyrolysis gases (equals $\dot{m}_g / \rho_e u_e C_M$),
β' = $\beta_c' + \beta_g'$ (equals $(\dot{m}_c + \dot{m}_g) / (\rho_e u_e C_M)$),
h_c = enthalpy of char,
h_g = enthalpy of pyrolysis gas,
h_w = enthalpy of gases at wall (heated surface),
α_w = absorptance,
q_{rad} = radiation input to ablating surface,
F = radiation view factor,
σ = Stefan-Boltzmann constant,
ϵ_w = emissivity,
T_w = wall (surface) temperature, and
q_{cond} = conduction into ablating material.

APPENDIX C

USER'S GUIDE FOR CMA CODE WITH ROUTINES TO MERGE HUNTER GRAPHITE OXIDATION SUBROUTINE WITH CMA ABLATION CALCULATIONS

APPENDIX C

User's Guide for CMA Code with Routines to Merge Hunter Graphite Oxidation Subroutines with CMA Ablation Calculations

The new input variables (Table C.1) are listed on a single line, which is the last line in the CMA input file. This line is an addition to the previous format and must be present whether the new features are used or not. It follows the existing JTBL parameter, which is used to select the method for computing graphite oxidation (i.e., values are either read from the surface thermochemistry (ST) tables in CMA or computed by the Hunter subroutine.)

Table C.1
New Inputs for CMA code.

Variable	Columns	Format	Description
IBLOPT	1-5	I5	Not used
IOPTN	6-10	I5	Merge Hunter subroutine and surface thermochemistry table ablation curves. 0 = This feature not evoked. 1 = Merge curves at constant wall temperature (TCRIT). 2 = Merge curves at wall temperature corresponding to a constant value of β' (BPCRIT). 3 = Search for temperature that produces smoothest curve.
TCRIT	11-20	F10.4	Constant wall temperature at which Hunter and surface thermochemistry table ablation curves are merged. This parameter is only used when IOPTN = 1.
BPCRIT	21-30	F10.4	Value of β' criterion for finding merge temperature. This parameter is only used when IOPTN = 2.
IMSG	31-35	I5	Status messages for new features. 0 = Do not print any messages. 1 = Print 1st level messages. 2 = Print 1st and 2nd level messages. 3 = Print 1st, 2nd and 3rd level messages. IMSG = 2 and 3 are primarily for debugging. They will produce significant output.
TABCN	36-45	F10.4	Computes ablation threshold temperature for ablating material. < = 0.0, Search for threshold temperature. > = 0.0, Material ablates at T_{wall} > TABCN. This feature is only active when IOPTN ≠ 0.
MITER	46-50	I5	Frequency at which merge factor and material ablation threshold temperature is recomputed.

The first input variable, IOPTN, evokes the routines that merge the Hunter oxidation subroutine with the mainstream CMA calculations. The merge routines cause the Hunter subroutine to be used for the oxidation calculations and the ST tables to be used for the sublimation calculations. They also compute and apply a factor (merge factor) on the Hunter ablation curve, which makes it continuous with the ST ablation curve.

The user has three options for specifying the transition temperature criterion (for switching from the Hunter subroutine to the ST tables). The transition can be at a constant wall temperature (TCRIT), at the temperature that corresponds to a constant value of β' (BPCRIT), or found using a procedure that searches for the temperature that gives the smoothest transition between the Hunter and ST ablation curves. As a warning, these methods increase in complexity from the user-specified constant temperature criteria to the search for the smoothest merge temperature, and computation time will also increase. The first two options are relatively inexpensive and the last is most expensive.

The input variable TABCN is used to specify the temperature at which the material begins to ablate (i.e., an ablation threshold temperature). The user can specify a constant ablation threshold temperature or he can activate the FDTABC module, which computes this value using a rewritten form of the Hunter algorithm for a temperature corresponding to a negligible value of β' (0.00001). This feature is only active when the Hunter subroutine and the merge feature are evoked.

The input variable MITER is the frequency of iteration steps at which the merge factor and the ablation threshold temperature are recomputed. For a trajectory with severe transients, these values should be recomputed every iteration step. On the other hand, for a trajectory with small transients, recomputing every five iterations may be sufficient. When MITER is a value other than 1, the user should run a sample problem to verify that the merge factors and ablator temperatures do not change drastically between iterations.

The last input variable, IMSG, is used to print status messages for the merge and ablator temperature operations with the normal CMA output. Four levels of messages are available. Most users will want none or first-level messages only. The other levels are primarily for debugging.

The executable program is called CMAV05. It is saved in the partitioned dataset 'BBE.CCC1.LOAD.MODULES'.

APPENDIX D

SAMPLE INPUT FILE USING NEW CMA CODE

APPENDIX D

Sample Input File Using New CMA Code

```
//CCC1H  JOB (11655,C,U,N),'CCC1',USER=CCC1,NOTIFY=CCC1,MSGCLASS=C
//*MAIN  ORG=RM001
//* SAMPLE JCL SET
//  EXEC PGM=CMAV05,REGION=2000K,TIME=1
//STEPLIB DD DSN=BBE.CCC1.LOAD.MODULES,DISP=SHR
//FT03F001  DD  UNIT=TEMP,
//          DCB=(RECFM=VB,LRECL=1200,BLKSIZE=4804),
//          SPACE=(TRK,(10,5),RLSE)
//FT06F001 DD  DSN=BBE.CCC1.CMA.FOR.PTB.OUTPUT01,DISP=(NEW,CATLG),
//          UNIT=SAVE,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=6233,BUFNO=1),
//          SPACE=(CYL,(120,60),RLSE)
//FT08F001  DD  DUMMY
//FT05F001  DD  *
```

Executable program

Write output to dataset

```
 GPHS--BROADSIDE STABLE -- (CMAV05)
 FLIGHT PATH ANGLE = -90
 SAMPLE JCL SET
A              114.7      114.7        0.        0.        0.    15000.
B              114.7      114.7        0.        0.        0.    15000.
C              114.7      114.7        0.        0.        0.    15000.
10 40            0.0      50.00       1.00      5.00      2.00     0.100      0.5
      10.0       40.0     0.0010        0.0       0.0       0.0       0.0    536.0
  1     1110.              .005     -1.0634
  1     1116.              .010
  1     1116.              .010
  1     1121.              .010
  1     1121.              .010
  1     1121.              .010
  1     1126.              .010
  1     1126.              .010
  1     1126.              .010
  1     1131.              .010
  1     1131.              .010
  1     1131.              .010
  1     1136.              .010
  1     1136.              .010
  1     1136.              .010
  1     1141.              .010
  1     1141.              .010
  1     1141.              .010
  1     1149.              .010
  1     1149.              .005                          7 0.0008
  3     1192.              .020
  3     1222.              .020
  3     1252.              .020
  3     1283.              .010                          7 0.014
  4     1331.              .010
  4     1336.              .020
  4     1341.              .040
  4     1346.              .040
  4     1351.              .040
  4     1356.              .0165                         7 0.0152
  5     1532.              .01338
  5     1546.              .01339                        7 0.0155
  6     1711.              .010                .06267
  6     1716.              .020                .06267
  6     1726.              .040                .06267
  6     1742.              .080                .06267
```

Nodal data

Up to 100 nodes permitted

```
6      1774.                .100                .06267
6      1814.                .100                .06267
6      1854.                .100                .06267
6      1894.                .10143              .06267
     0.0        0.0          0.       0.02       0.98
      460.0     0.175     0.02778       0.80       0.80
      710.0     0.225     0.02315       0.80       0.80
      960.0     0.290     0.02014       0.80       0.80
     1210.0     0.330     0.01759       0.80       0.80
     1460.0     0.360     0.01551       0.80       0.80
     1710.0     0.390     0.01377       0.80       0.80
     1960.0     0.410     0.01243       0.80       0.80
     2210.0     0.430     0.01123       0.80       0.80
     2460.0     0.450     0.01076       0.80       0.80
     2960.0     0.480     0.00909       0.80       0.80
     3460.0     0.510     0.00828       0.80       0.80
     3960.0     0.530     0.00741       0.80       0.80
     4460.0     0.550     0.00694       0.80       0.80
     5460.0     0.575     0.00625       0.80       0.80
-1   7960.0     0.575     0.00625       0.80       0.80
      460.0     0.175     0.02778       0.80       0.80
      710.0     0.225     0.02315       0.80       0.80
      960.0     0.290     0.02014       0.80       0.80
     1210.0     0.330     0.01759       0.80       0.80
     1460.0     0.360     0.01551       0.80       0.80
     1710.0     0.390     0.01377       0.80       0.80
     1960.0     0.410     0.01243       0.80       0.80
     2210.0     0.430     0.01123       0.80       0.80
     2460.0     0.450     0.01076       0.80       0.80
     2960.0     0.480     0.00909       0.80       0.80
     3460.0     0.510     0.00828       0.80       0.80
     3960.0     0.530     0.00741       0.80       0.80
     4460.0     0.550     0.00694       0.80       0.80
     5460.0     0.575     0.00625       0.80       0.80
-1   7960.0     0.575     0.00625       0.80       0.80
 3014.40
      672.0     0.214    0.0000122      0.80       0.80
      852.0     0.265    0.0000144      0.80       0.80
     1032.0     0.312    0.0000169      0.80       0.80
     1212.0     0.351    0.0000197      0.80       0.80
     1392.0     0.380    0.0000225      0.80       0.80
     1572.0     0.406    0.0000239      0.80       0.80
     1752.0     0.424    0.0000253      0.80       0.80
     1932.0     0.440    0.0000267      0.80       0.80
     2112.0     0.450    0.0000281      0.80       0.80
     2292.0     0.461    0.0000297      0.80       0.80
     2472.0     0.470    0.0000311      0.80       0.80
     2652.0     0.478    0.0000325      0.80       0.80
     2832.0     0.482    0.0000339      0.80       0.80
     3012.0     0.487    0.0000356      0.80       0.80
     3460.0     0.500    0.0000392      0.80       0.80
     4460.0     0.520    0.0000475      0.80       0.80
-1  10460.0     0.520    0.0000503      0.80       0.80
 40114.7
      460.0     0.175     0.02778       0.80       0.80
      710.0     0.225     0.02315       0.80       0.80
      960.0     0.290     0.02014       0.80       0.80
     1210.0     0.330     0.01759       0.80       0.80
     1460.0     0.360     0.01551       0.80       0.80
     1710.0     0.390     0.01377       0.80       0.80
```

```
     1960.0    0.410      0.01243    0.80       0.80
     2210.0    0.430      0.01123    0.80       0.80
     2460.0    0.450      0.01076    0.80       0.80
     2960.0    0.480      0.00909    0.80       0.80
     3460.0    0.510      0.00828    0.80       0.80
     3960.0    0.530      0.00741    0.80       0.80
     4460.0    0.550      0.00694    0.80       0.80
     5460.0    0.575      0.00625    0.80       0.80
-1   7960.0    0.575      0.00625    0.80       0.80
 501625.
      460.0    0.0305     0.0239     0.084      0.084
     1460.0    0.0347     0.0219     0.137      0.137
     2460.0    0.0388     0.0212     0.191      0.191
     3460.0    0.0429     0.0182     0.242      0.242
     4460.0    0.0470     0.0181     0.298      0.298
     4910.0    0.0470     0.0181     0.620      0.620
-1  10460.0    0.0470     0.0181     0.620      0.620
 60590.
   460.          .0587     .0000664   .591       .591
   560.          .0620     .0000672   .599       .599
  1032.          .0780     .0000705   .643       .643
  1212.          .0794     .0000739   .659       .659
  1392.          .0805     .0000875   .676       .676
  1572.          .0811     .0000903   .692       .692
  1752.          .0817     .0000931   .709       .709
  1932.          .0821     .0001514   .725       .725
  2112.          .0825     .0001639   .742       .742
  2472.          .0830     .0001892   .775       .775
  2652.          .0832     .0002017   .791       .791
  2960.          .0835     .0002075   .819       .819
  3460.          .0838     .0002167   .865       .865
  4460.          .0840     .0002355   .911       .911
  5460.          .0840     .0002542   .956       .956
+110460.         .0840     .0002542   .956       .956
1      0.        5000.     10000.
       .1          .1        .1
      12.0      1.700     0.800      1.000      1.000 0 0 0 0 0     8000.
```

Time-table

120 entries permitted

0.0	43622.8	0.09	42.628	22.73	0.00034	348.0	46746.	0.0
0.25	43629.4	0.19	57.119	40.78	0.00062	336.3	46753.	0.0
0.50	43636.2	0.37	78.014	76.04	0.00115	324.6	46760.	0.0
0.75	43644.2	0.74	107.316	143.82	0.00218	313.0	46767.	0.0
1.00	43650.8	1.47	150.322	282.07	0.00428	301.3	46773.	0.0
1.25	43657.4	2.91	211.254	556.89	0.00844	289.6	46778.	0.0
1.50	43661.9	5.78	293.281	1073.13	0.01626	277.9	46780.	0.0
1.75	43657.4	15.38	407.115	2068.20	0.03135	266.2	46778.	0.0
2.00	43640.1	44.94	547.836	3748.09	0.05682	254.5	46766.	0.0
2.25	43598.2	110.79	713.722	6373.13	0.09667	242.8	46741.	0.0
2.50	43514.7	244.76	912.271	10447.53	0.15864	231.2	46693.	0.0
2.75	43367.6	493.88	1145.763	16575.96	0.25214	219.5	46610.	0.0
3.00	43126.7	899.27	1414.083	25987.52	0.38881	207.9	46478.	0.0
3.25	42748.6	1581.84	1727.713	38610.24	0.59[illegible]	[illegible]5.3	46271.	0.0
3.50	42164.8	2605.77	2093.353	57988.98	0.8[illegible]	184.8	45953.	0.0
3.75	41290.5	4191.64	2489.822	0.0	1.[illegible]	173.3	45472.	0.0
3.95	40277.6	6032.64	2847.254	0.0	1.8[illegible]2	164.1	44911.	0.0
4.10	39338.6	7685.46	3103.646	0.0	2.[illegible]340	157.6	44385.	0.0
4.22	38443.3	9158.19	3310.637	0.0	2.72976	152.5	43877.	0.0
4.32	37530.3	10478.05	3491.145	0.0	3.19620	148.2	43354.	0.0
4.42	36476.7	11885.39	3656.354	0.0	3.72678	143.9	42783.	0.0
4.52	35269.6	13268.12	3798.086	0.0	4.32249	139.6	42031.	0.0
4.62	33899.2	14236.21	3906.083	0.0	4.97773	135.5	41207.	0.0

4.72	32359.8	14945.10	3972.378	0.0	5.68821	131.4	40262.	0.0
4.82	30652.5	14640.01	3986.267	0.0	6.43489	127.4	39187.	0.0
4.92	28786.5	13722.39	3941.544	0.0	7.19944	123.6	37978.	0.0
5.02	26780.8	11248.63	3833.005	0.0	7.95015	119.8	36633.	0.0
5.12	24664.1	8495.31	3660.946	0.0	8.65439	116.2	35158.	0.0
5.22	22475.3	5570.58	3430.057	0.0	9.27424	112.8	33564.	0.0
5.32	20260.3	2822.21	3150.542	0.0	9.77572	109.5	31870.	0.0
5.42	18067.8	1225.46	2836.325	0.0	10.13010	106.4	30100.	0.0
5.52	15950.3	655.31	2498.031	0.0	10.26720	103.5	28285.	0.0
5.62	13958.3	380.10	2159.229	0.0	10.21262	100.8	26464.	0.0
5.72	12123.1	233.62	1836.626	0.0	9.99701	98.2	24667.	0.0
5.82	10462.5	0.0	1541.068	0.0	9.65201	95.9	22920.	0.0
5.92	8984.2	0.0	1278.214	0.0	9.20298	93.6	21245.	0.0
6.02	7686.5	0.0	1050.029	0.0	8.67376	91.6	19657.	0.0
6.12	6560.5	0.0	856.810	0.0	8.10546	89.7	18167.	0.0
6.22	5592.5	0.0	695.483	0.0	7.51296	88.0	16781.	0.0
6.32	4766.5	0.0	562.809	0.0	6.92184	86.4	15500.	0.0
6.42	4065.3	0.0	454.782	0.0	6.34671	84.9	14323.	0.0
6.52	3472.2	0.0	367.437	0.0	5.79764	83.5	13247.	0.0
6.62	2971.6	0.0	297.232	0.0	5.28342	82.2	12265.	0.0
6.72	2549.5	0.0	240.911	0.0	4.80546	81.0	11371.	0.0
6.82	2193.5	0.0	195.823	0.0	4.36690	79.9	10558.	0.0
6.92	1893.0	0.0	159.760	0.0	3.96887	78.9	9821.	0.0
7.02	1638.9	0.0	130.827	0.0	3.60677	78.0	9150.	0.0
7.12	1423.6	0.0	107.592	0.0	3.28012	77.1	8542.	0.0
7.22	1240.6	0.0	88.869	0.0	2.98537	76.3	7988.	0.0
7.32	1084.8	0.0	73.742	0.0	2.72031	75.5	7484.	0.0
7.42	951.6	0.0	61.477	0.0	2.48248	74.8	7025.	0.0
7.52	837.4	0.0	51.489	0.0	2.26866	74.1	6605.	0.0
7.62	739.2	0.0	43.326	0.0	2.07687	73.4	6222.	0.0
7.72	654.4	0.0	36.622	0.0	1.90437	72.8	5872.	0.0
7.82	580.9	0.0	29.762	0.0	1.74954	72.3	5550.	0.0
7.92	517.1	0.0	25.146	0.0	1.60959	71.7	5255.	0.0
8.02	461.4	0.0	21.317	0.0	1.48443	71.2	4983.	0.0
8.12	412.7	0.0	19.111	0.0	1.30149	70.7	4732.	0.0
8.22	370.0	0.0	16.358	0.0	1.20827	70.3	4501.	0.0
8.32	332.4	0.0	14.038	0.0	1.12320	69.8	4287.	0.0
8.42	299.1	0.0	12.082	0.0	1.04621	69.4	4088.	0.0
8.52	269.7	0.0	10.424	0.0	0.97597	69.0	3904.	0.0
8.62	243.5	0.0	9.016	0.0	0.91209	68.6	3733.	0.0
8.72	220.3	0.0	7.817	0.0	0.85384	68.3	3574.	0.0
8.82	199.4	0.0	6.791	0.0	0.80061	67.9	3425.	0.0
8.92	180.8	0.0	5.912	0.0	0.75187	67.6	3287.	0.0
9.02	164.1	0.0	5.156	0.0	0.70713	67.3	3157.	0.0
9.12	149.0	0.0	4.505	0.0	0.66623	67.0	3036.	0.0
9.22	135.4	0.0	3.941	0.0	0.62852	66.7	2922.	0.0
9.32	123.1	0.0	3.452	0.0	0.59369	66.4	2815.	0.0
9.42	112.0	0.0	3.029	0.0	0.56188	66.1	2714.	0.0
9.52	101.9	0.0	2.659	0.0	0.53219	65.8	2620.	0.0
9.62	92.7	0.0	2.336	0.0	0.50467	65.6	2530.	0.0
9.72	84.3	0.0	2.055	0.0	0.47939	65.3	2446.	0.0
9.82	76.7	0.0	1.808	0.0	0.45584	65.1	2367.	0.0
9.92	69.7	0.0	1.591	0.0	0.43416	64.8	2292.	0.0
10.02	63.3	0.0	1.400	0.0	0.41389	64.6	2221.	0.0
10.12	57.4	0.0	1.232	0.0	0.39519	64.4	2153.	0.0
10.22	52.0	0.0	1.083	0.0	0.37778	64.2	2090.	0.0
10.32	47.0	0.0	0.951	0.0	0.36154	64.0	2029.	0.0
10.42	42.4	0.0	0.834	0.0	0.34638	63.8	1971.	0.0
10.52	38.2	0.0	0.730	0.0	0.33219	63.6	1917.	0.0
10.62	34.2	0.0	0.637	0.0	0.31903	63.4	1865.	0.0

	10.72	30.6	0.0	0.554	0.0	0.30668	63.2	1815.	0.0
	10.82	27.2	0.0	0.480	0.0	0.29520	63.0	1768.	0.0
	10.92	24.0	0.0	0.414	0.0	0.28440	62.9	1722.	0.0
	11.02	21.1	0.0	0.355	0.0	0.27424	62.7	1679.	0.0
	11.22	15.8	0.0	0.254	0.0	0.25582	62.4	1599.	0.0
	11.42	11.2	0.0	0.172	0.0	0.23956	62.1	1525.	0.0
	11.62	7.1	0.0	0.105	0.0	0.22500	61.8	1456.	0.0
	11.84	3.3	0.0	0.047	0.0	0.21129	61.4	1389.	0.0
	12.06	-0.1	0.0	-0.002	0.0	0.19895	61.1	1325.	0.0
	12.46	-5.0	0.0	-0.064	0.0	0.18129	60.6	1229.	0.0
	12.91	-9.4	0.0	-0.112	0.0	0.16557	60.1	1136.	0.0
	13.43	-13.4	0.0	-0.149	0.0	0.15199	59.5	1046.	0.0
	14.07	-16.8	0.0	-0.176	0.0	0.14087	58.9	959.	0.0
	14.86	-19.9	0.0	-0.197	0.0	0.13228	58.2	875.	0.0
	19.65	-27.7	0.0	-0.234	0.0	0.12044	54.7	614.	0.0
	29.43	-31.1	0.0	-0.249	0.0	0.13572	49.7	452.	0.0
	39.43	-32.1	0.0	-0.263	0.0	0.15994	45.5	392.	0.0
	49.43	-32.7	0.0	-0.278	0.0	0.18739	41.8	355.	0.0
	59.43	-33.1	0.0	-0.292	0.0	0.21725	38.4	326.	0.0
	69.43	-32.6	0.0	-0.297	0.0	0.24953	35.2	301.	0.0
	79.43	-30.3	0.0	-0.286	0.0	0.28359	32.3	284.	0.0
	89.43	-28.1	0.0	-0.275	0.0	0.31953	29.5	269.	0.0
	99.43	-26.0	0.0	-0.262	0.0	0.35737	26.9	257.	0.0
	109.43	-24.0	0.0	-0.249	0.0	0.39695	24.4	245.	0.0
	119.43	-22.0	0.0	-0.236	0.0	0.43827	22.0	235.	0.0
	129.43	-20.2	0.0	-0.221	0.0	0.48124	19.7	226.	0.0
	139.43	-18.3	0.0	-0.206	0.0	0.52610	17.5	218.	0.0
	149.43	-16.6	0.0	-0.191	0.0	0.57253	15.3	210.	0.0
	159.43	-14.9	0.0	-0.175	0.0	0.62049	13.3	203.	0.0
	169.43	-13.2	0.0	-0.159	0.0	0.67020	11.3	197.	0.0
	179.43	-11.6	0.0	-0.143	0.0	0.72130	9.3	191.	0.0
	189.43	-10.0	0.0	-0.126	0.0	0.77405	7.5	186.	0.0
	199.43	-8.5	0.0	-0.109	0.0	0.82833	5.6	180.	0.0
	209.43	-7.0	0.0	-0.091	0.0	0.88426	3.8	176.	0.0
	219.43	-5.5	0.0	-0.074	0.0	0.94171	2.1	171.	0.0
	229.43	-4.1	0.0	-0.056	0.0	1.00058	0.4	167.	0.0
1	231.97	-3.8	0.0	-0.051	0.0	1.01555	0.0	166.	0.0
	1.	1.0	0.5 0	0	0	0	0	0.	

0.00001	0.0	60.000002687.99220.0			6928.273	6928.273	1	C*		C I
0.00001	0.0	50.000002687.65360.0			6903.277	6903.277	1	C*		C I
0.00001	0.0	30.000002686.10300.0			6810.352	6810.352	1	C*		C I
0.00001	0.0	20.000002684.24730.0			6695.957	6695.957	1	C*		C I
0.00001	0.0	10.000002679.02490.0			6369.059	6369.059	1	C*		C I
0.00001	0.0	5.000002669.34200.0			5792.414	5792.414	1	C*		C I
0.00001	0.0	1.000002613.71970.0			3182.023	3182.023	1	C*		C I
0.00001	0.0	0.350002525.43990.0			1236.478	1236.478	1	C*		C I
0.00001	0.0	0.200002394.70140.0			433.386	433.386	1	C*		C I
0.00001	0.0	0.190002359.54710.0			362.322	362.322	1	C*		C I
0.00001	0.0	0.180002283.43990.0			275.831	275.831	1	C*		C I
0.00001	0.0	0.175001986.69210.0			150.001	150.001	1	C*		C I
0.00001	0.0	0.174911728.07060.0			70.276	70.276	1	C*		C I
0.00001	0.0	0.1748 1666.67	0.0		51.10	51.10	1	C*		
0.00001	0.0	0.1743 1450.0	0.0		-15.3	-15.3	1	C*		GE
0.00001	0.0	0.1686 1350.0	0.0		-62.9	-62.9	1	C*		GE
0.00001	0.0	0.1252 1250.0	0.0		-238.5	-238.5	1	C*		GE
0.00001	0.0	0.0813 1200.0	0.0		-349.1	-349.1	1	C*		GE
0.00001	0.0	0.0429 1150.0	0.0		-98.4	-98.4	1	C*		GE
0.00001	0.0	0.0193 1100.0	0.0		60.4	60.4	1	C*		GE
0.00001	0.0	0.0027 1000.0	0.0		159.2	159.2	1	C*		GE
0.00001	0.0	0.0 1000.0	0.0		250.0	250.0	0			AIR

Surface thermochemistry tables

20 pressure tables with up to
30 mass loss parameters ($\dot{w}_c$) permitted.

0.00001	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.00001	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.00001	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.00001	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.00001	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.00001	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.00001	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.00001	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.0001	0.0	60.000002	881.5923	0.0	6901.996	6901.996	1	C*	C I
0.0001	0.0	50.000002	881.1843	0.0	6877.484	6877.484	1	C*	C I
0.0001	0.0	30.000002	879.3328	0.0	6786.594	6786.594	1	C*	C I
0.0001	0.0	20.000002	877.1240	0.0	6674.496	6674.496	1	C*	C I
0.0001	0.0	10.000002	870.9246	0.0	6353.332	6353.332	1	C*	C I
0.0001	0.0	5.000002	859.3965	0.0	5783.715	5783.715	1	C*	C I
0.0001	0.0	1.000002	794.3921	0.0	3206.576	3206.576	1	C*	C I
0.0001	0.0	0.350002	692.3621	0.0	1279.992	1279.992	1	C*	C I
0.0001	0.0	0.200002	542.2241	0.0	478.635	478.635	1	C*	C I
0.0001	0.0	0.190002	501.9099	0.0	406.375	406.375	1	C*	C I
0.0001	0.0	0.180002	414.6606	0.0	316.658	316.658	1	C*	C I
0.0001	0.0	0.175002	078.7629	0.0	178.367	178.367	1	C*	C I
0.0001	0.0	0.174911	794.6394	0.0	90.524	90.524	1	C*	C I
0.0001	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.0001	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.0001	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.0001	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.0001	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.0001	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.0001	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.0001	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.0001	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
0.0001	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0001	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0001	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0001	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0001	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0001	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0001	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0001	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.001	0.0	60.000003	105.7739	0.0	6908.277	6908.277	1	C*	C I
0.001	0.0	50.000003	105.1931	0.0	6885.961	6885.961	1	C*	C I
0.001	0.0	30.000003	102.9587	0.0	6795.809	6796.809	1	C*	C I
0.001	0.0	20.000003	100.3018	0.0	6686.586	6686.586	1	C*	C I
0.001	0.0	10.000003	092.8752	0.0	6370.063	6370.063	1	C*	C I
0.001	0.0	5.000003	079.0706	0.0	5806.551	5806.551	1	C*	C I
0.001	0.0	1.000003	002.3555	0.0	3252.220	3252.220	1	C*	C I
0.001	0.0	0.350002	883.2012	0.0	1335.477	1335.477	1	C*	C I
0.001	0.0	0.200002	708.9353	0.0	530.768	530.768	1	C*	C I
0.001	0.0	0.190002	662.2173	0.0	456.612	456.612	1	C*	C I
0.001	0.0	0.180002	561.1631	0.0	362.507	362.507	1	C*	C I
0.001	0.0	0.175002	178.0625	0.0	209.068	209.068	1	C*	C I
0.001	0.0	0.174911	863.2866	0.0	111.481	111.481	1	C*	C I
0.001	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.001	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.001	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.001	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.001	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.001	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.001	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.001	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.001	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

0.001	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.001	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.001	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.001	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.001	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.001	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.001	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.001	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.0020	0.0	60.000003	180.3235	0.0	6917.563	6917.563	1	C*	
0.0020	0.0	50.000003	179.7017	0.0	6895.371	6895.371	1	C*	
0.0020	0.0	30.000003	177.3323	0.0	6806.711	6806.711	1	C*	
0.0020	0.0	20.000003	174.5144	0.0	6697.027	6697.027	1	C*	
0.0020	0.0	10.000003	166.6992	0.0	6381.750	6381.750	1	C*	
0.0020	0.0	5.000003	152.5498	0.0	5819.109	5819.109	1	C*	
0.0020	0.0	1.000003	071.7180	0.0	3270.276	3270.276	1	C*	
0.0020	0.0	0.350002	943.2422	0.0	1363.521	1363.521	1	C*	
0.0020	0.0	0.200002	757.2439	0.0	548.953	548.953	1	C*	
0.0020	0.0	0.190002	707.1826	0.0	472.821	472.821		C*	
0.0020	0.0	0.180002	599.1089	0.0	375.333	375.333	1	C*	
0.0020	0.0	0.175002	249.7517	0.0	231.768	231.768	1	C*	
0.0020	0.0	0.174902	161.8542	0.0	203.822	203.822	1	C*	
0.0020	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.0020	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.0020	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.0020	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.0020	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.0020	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.0020	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.0020	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.0020	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
0.0020	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0020	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0020	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0020	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0020	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0020	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0020	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0020	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.0050	0.0	60.000003	284.6409	0.0	6934.531	6934.531	1	C*	
0.0050	0.0	50.000003	283.9644	0.0	6912.527	6912.527	1	C*	
0.0050	0.0	30.000003	281.4011	0.0	6824.453	6824.453	1	C*	
0.0050	0.0	20.000003	278.3557	0.0	6715.402	6715.402	1	C*	
0.0050	0.0	10.000003	269.8733	0.0	6401.652	6401.652	1	C*	
0.0050	0.0	5.000003	254.6704	0.0	5841.047	5841.047	1	C*	
0.0050	0.0	1.000003	167.9294	0.0	3297.372	3297.372	1	C*	
0.0050	0.0	0.350003	074.1685	0.0	1382.595	1382.595	1	C*	
0.0050	0.0	0.200002	831.9084	0.0	572.696	572.696	1	C*	
0.0050	0.0	0.190002	778.4961	0.0	495.400	495.400	1	C*	
0.0050	0.0	0.180002	663.2241	0.0	395.472	395.472	1	C*	
0.0050	0.0	0.175002	293.1860	0.0	245.230	245.230	1	C*	
0.0050	0.0	0.174902	200.8775	0.0	215.878	215.878	1	C*	
0.0050	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.0050	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.0050	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.0050	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.0050	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.0050	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.0050	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.0050	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.0050	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

0.0050	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0050	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0050	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0050	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0050	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0050	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0050	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0050	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.01	0.0	60.000003	368.3022	0.0	6950.918	6950.918	1	C*	C I
0.01	0.0	50.000003	367.5837	0.0	6928.996	6928.996	1	C*	C I
0.01	0.0	30.000003	364.8589	0.0	6841.363	6841.363	1	C*	C I
0.01	0.0	20.000003	361.6230	0.0	6732.754	6732.754	1	C*	C I
0.01	0.0	10.000003	352.6174	0.0	6419.977	6419.977	1	C*	C I
0.01	0.0	5.000003	336.1194	0.0	5860.250	5860.250	1	C*	C I
0.01	0.0	1.000003	244.4514	0.0	3319.316	3319.316	1	C*	C I
0.01	0.0	0.350003	103.5095	0.0	1403.857	1403.857	1	C*	C I
0.01	0.0	0.200002	898.5659	0.0	590.734	590.734	1	C*	C I
0.01	0.0	0.190002	843.6956	0.0	513.877	513.877	1	C*	C I
0.01	0.0	0.180002	725.0874	0.0	413.964	413.964	1	C*	C I
0.01	0.0	0.175002	283.2512	0.0	241.694	241.694	1	C*	C I
0.01	0.0	0.174911	930.5713	0.0	132.089	132.089	1	C*	C I
0.01	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.01	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.01	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.01	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.01	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.01	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.01	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.01	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.01	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
0.01	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.01	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.01	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.01	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.01	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.01	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.01	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.01	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.0220	0.0	60.000003	468.9141	0.0	6973.277	6973.277	1	C*	
0.0220	0.0	50.000003	468.1433	0.0	6951.520	6951.520	1	C*	
0.0220	0.0	30.000003	465.2319	0.0	6864.355	6864.355	1	C*	
0.0220	0.0	20.000003	461.7368	0.0	6756.277	6756.277	1	C*	
0.0220	0.0	10.000003	452.0837	0.0	6444.684	6444.684	1	C*	
0.0220	0.0	5.000003	434.8496	0.0	5886.863	5886.863	1	C*	
0.0220	0.0	1.000003	337.1469	0.0	3348.694	3348.694	1	C*	
0.0220	0.0	0.350003	187.4421	0.0	1431.739	1431.739	1	C*	
0.0220	0.0	0.200002	961.0547	0.0	613.809	613.809	1	C*	
0.0220	0.0	0.190002	901.3787	0.0	534.309	534.309	1	C*	
0.0220	0.0	0.180002	772.6692	0.0	429.841	429.841	1	C*	
0.0220	0.0	0.175002	364.3726	0.0	267.330	267.330	1	C*	
0.0220	0.0	0.174902	263.9390	0.0	235.396	235.396	1	C*	
0.0220	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.0220	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.0220	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.0220	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.0220	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.0220	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.0220	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.0220	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.0220	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

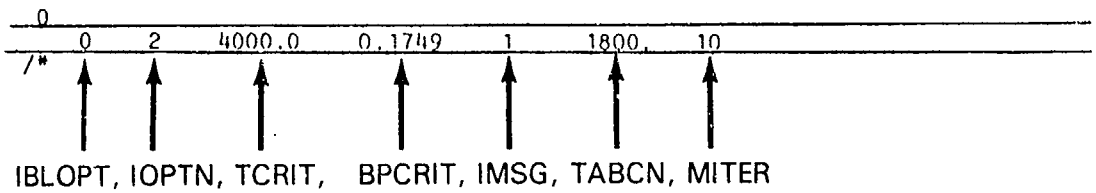
0.0220	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0220	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0220	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0220	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0220	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0220	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0220	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0220	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.0460	0.0	60.000003	568.741	90.0	6997.809	6997.809	1	C*	
0.0460	0.0	50.000003	567.918	50.0	6976.176	6976.176	1	C*	
0.0460	0.0	30.000003	564.780	50.0	6889.453	6889.453	1	C*	
0.0460	0.0	20.000003	561.057	40.0	6781.793	6781.793	1	C*	
0.0460	0.0	10.000003	550.742	70.0	6471.188	6471.188	1	C*	
0.0460	0.0	5.000003	532.345	20.0	5914.496	5914.496	1	C*	
0.0460	0.0	1.000003	428.419	40.0	3377.774	3377.774	1	C*	
0.0460	0.0	0.350003	269.678	50.0	1458.450	1458.450	1	C*	
0.0460	0.0	0.200003	039.754	90.0	636.239	636.239	1	C*	
0.0460	0.0	0.190002	966.188	70.0	554.787	554.787	1	C*	
0.0460	0.0	0.180002	829.750	50.0	447.737	447.737	1	C*	
0.0460	0.0	0.175002	399.698	00.0	278.312	278.312	1	C*	
0.0460	0.0	0.174902	294.684	60.0	244.927	244.927	1	C*	
0.0460	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.0460	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.0460	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.0460	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.0460	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.0460	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.0460	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.0460	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.0460	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
0.0460	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0460	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0460	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0460	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0460	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0460	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0460	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0460	0.0	0.0	0001	0.0	0.0	0.0	0		
0.1	0.0	60.000003	676.376	50.0	7027.430	7027.430	1	C*	C I
0.1	0.0	50.000003	675.489	50.0	7005.883	7005.883	1	C*	C I
0.1	0.0	30.000003	676.106	90.0	6919.547	6919.547	1	C*	C I
0.1	0.0	20.000003	672.102	10.0	6812.309	6812.309	1	C*	C I
0.1	0.0	10.000003	661.007	10.0	6502.574	6502.574	1	C*	C I
0.1	0.0	5.000003	641.208	30.0	5945.016	5945.016	1	C*	C I
0.1	0.0	1.000003	529.908	70.0	3408.819	3408.819	1	C*	C I
0.1	0.0	0.350003	360.418	90.0	1486.246	1486.246	1	C*	C I
0.1	0.0	0.200003	115.151	90.0	659.078	659.078	1	C*	C I
0.1	0.0	0.190003	049.502	40.0	578.657	578.657	1	C*	C I
0.1	0.0	0.180002	907.610	60.0	471.172	471.172	1	C*	C I
0.1	0.0	0.175002	389.571	80.0	274.760	274.760	1	C*	C I
0.1	0.0	0.174911	994.118	40.0	151.611	151.611	1	C*	C I
0.1	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.1	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.1	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.1	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.1	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.1	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.1	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.1	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.10	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

0.10	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.10	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.10	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.10	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.10	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.10	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.10	0.0	0.0	100.0	0.0	23.8	23.8	0		
0.10	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.2150	0.0	60.000003797.61740.0			7060.477	7060.477	1	C*	
0.2150	0.0	50.000003796.66500.0			7039.090	7039.090	1	C*	
0.2150	0.0	30.000003793.01170.0			6953.199	6953.199	1	C*	
0.2150	0.0	20.000003788.69700.0			6846.414	6846.414	1	C*	
0.2150	0.0	10.000003776.76000.0			6537.637	6537.637	1	C*	
0.2150	0.0	5.000003755.54860.0			5982.898	5982.898	1	C*	
0.2150	0.0	1.000003636.56670.0			3486.366	3486.366	1	C*	
0.2150	0.0	0.350003455.95630.0			1519.255	1519.255	1	C*	
0.2150	0.0	0.200003194.93900.0			685.500	685.500	1	C*	
0.2150	0.0	0.190003125.17090.0			603.449	603.449	1	C*	
0.2150	0.0	0.180002953.96360.0			486.518	486.518	1	C*	
0.2150	0.0	0.175002471.17650.0			300.557	300.557	1	C*	
0.2150	0.0	0.174902355.32890.0			263.750	263.750	1	C*	
0.2150	0.0	0.1748 1666.67		0.0	51.10	51.10	1	C*	
0.2150	0.0	0.1743 1450.0		0.0	-15.3	-15.3	1	C*	GE
0.2150	0.0	0.1686 1350.0		0.0	-62.9	-62.9	1	C*	GE
0.2150	0.0	0.1252 1250.0		0.0	-238.5	-238.5	1	C*	GE
0.2150	0.0	0.0813 1200.0		0.0	-349.1	-349.1	1	C*	GE
0.2150	0.0	0.0429 1150.0		0.0	-98.4	-98.4	1	C*	GE
0.2150	0.0	0.0193 1100.0		0.0	60.4	60.4	1	C*	GE
0.2150	0.0	0.0027 1000.0		0.0	159.2	159.2	1	C*	GE
0.2150	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
0.2150	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.2150	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.2150	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.2150	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.2150	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.2150	0.0	0.0	140.0	0.0	33.3	33.3	0		
0.2150	0.0	0.0	100.0	0.0	23.7	23.7	0		
0.2150	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.4640	0.0	60.000003923.36870.0			7097.602	7097.602	1	C*	
0.4640	0.0	50.000003922.34350.0			7076.340	7076.340	1	C*	
0.4640	0.0	30.000003918.39330.0			6990.828	6990.828	1	C*	
0.4640	0.0	20.000003913.73240.0			6884.449	6884.449	1	C*	
0.4640	0.0	10.000003900.84910.0			6576.480	6576.480	1	C*	
0.4640	0.0	5.000003877.99560.0			6022.477	6022.477	1	C*	
0.4640	0.0	1.000003750.24930.0			3484.573	3484.573	1	C*	
0.4640	0.0	0.350003556.89260.0			1552.108	1552.108	1	C*	
0.4640	0.0	0.200003277.59280.0			711.506	711.506	1	C*	
0.4640	0.0	0.190003202.85060.0			627.803	627.803	1	C*	
0.4640	0.0	0.180003041.94780.0			513.834	513.834	1	C*	
0.4640	0.0	0.175002504.48140.0			310.931	310.931	1	C*	
0.4640	0.0	0.174902382.65280.0			272.241	272.241	1	C*	
0.4640	0.0	0.1748 1666.67		0.0	51.10	51.10	1	C*	
0.4640	0.0	0.1743 1450.0		0.0	-15.3	-15.3	1	C*	GE
0.4640	0.0	0.1686 1350.0		0.0	-62.9	-62.9	1	C*	GE
0.4640	0.0	0.1252 1250.0		0.0	-238.5	-238.5	1	C*	GE
0.4640	0.0	0.0813 1200.0		0.0	-349.1	-349.1	1	C*	GE
0.4640	0.0	0.0429 1150.0		0.0	-98.4	-98.4	1	C*	GE
0.4640	0.0	0.0193 1100.0		0.0	60.4	60.4	1	C*	GE
0.4640	0.0	0.0027 1000.0		0.0	159.2	159.2	1	C*	GE
0.4640	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

0.4640	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.4640	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.4640	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.4640	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.4640	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.4640	0.0	0.0	140.0	0.0	33.3	33.3	0		
0.4640	0.0	0.0	100.0	0.0	23.7	23.7	0		
0.4640	0.0	0.0	.0001	0.0	0.0	0.0	0		
1.0	0.0	60.000004	057.6636	0.0	7138.723	7138.723	1	C*	C I
1.0	0.0	50.000004	056.5505	0.0	7117.508	7117.508	1	C*	C* I
1.0	0.0	30.000004	052.2742	0.0	7032.352	7032.352	1	C*	C* I
1.0	0.0	20.000004	047.2222	0.0	6926.297	6926.297	1	C*	C* I
1.0	0.0	10.000004	033.2773	0.0	6618.926	6618.926	1	C*	C* I
1.0	0.0	5.000004	009.4072	0.0	6061.332	6061.332	1	C*	C* I
1.0	0.0	1.000003	871.2676	0.0	3519.934	3519.934	1	C*	C* I
1.0	0.0	0.350003	662.6260	0.0	1582.190	1582.190	1	C*	C* I
1.0	0.0	0.200003	361.4016	0.0	735.431	735.431	1	C*	C* I
1.0	0.0	0.190003	280.5874	0.0	650.105	650.105	1	C*	C* I
1.0	0.0	0.180003	105.8206	0.0	532.485	532.485	1	C*	C* I
1.0	0.0	0.175002	486.3264	0.0	304.905	304.905	1	C*	C* I
1.0	0.0	0.174912	075.0688	0.0	176.557	176.557	1	C*	C* I
1.0	0.0	0.1748	1666.67	0.0	51.0	51.0	1	C*	
1.0	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
1.0	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
1.0	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
1.0	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
1.0	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
1.0	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
1.0	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
1.00	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
1.00	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
1.00	0.0	0.0	260.0	0.0	62.1	62.1	0		
1.00	0.0	0.0	240.0	0.0	57.3	57.3	0		AIR
1.00	0.0	0.0	200.0	0.0	47.7	47.7	0		AIR
1.00	0.0	0.0	180.0	0.0	42.9	42.9	0		
1.00	0.0	0.0	140.0	0.0	33.2	33.2	0		
1.00	0.0	0.0	100.0	0.0	23.5	23.5	0		
1.00	0.0	0.0	.0001	0.0	0.0	0.0	0		
2.1550	0.0	60.000004	201.6563	0.0	7183.977	7183.977	1	C*	
2.1550	0.0	50.000004	200.4336	0.0	7162.898	7162.898	1	C*	
2.1550	0.0	30.000004	195.7891	0.0	7078.117	7078.117	1	C*	
2.1550	0.0	20.000004	190.3047	0.0	6972.473	6972.473	1	C*	
2.1550	0.0	10.000004	175.1836	0.0	6665.863	6665.863	1	C*	
2.1550	0.0	5.000004	148.4453	0.0	6112.777	6112.777	1	C*	
2.1550	0.0	1.000003	999.9824	0.0	3568.790	3568.790	1	C*	
2.1550	0.0	0.350003	776.3494	0.0	1622.460	1622.460	1	C*	
2.1550	0.0	0.200003	452.9373	0.0	765.805	765.805	1	C*	
2.1550	0.0	0.190003	366.0393	0.0	678.253	678.253	1	C*	
2.1550	0.0	0.180003	178.7424	0.0	556.226	556.226	1	C*	
2.1550	0.0	0.175002	563.0559	0.0	329.181	329.181	1	C*	
2.1550	0.0	0.174902	428.7312	0.0	286.572	286.572	1	C*	
2.1550	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
2.1550	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
2.1550	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
2.1550	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
2.1550	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
2.1550	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
2.1550	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
2.1550	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
2.1550	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

2.1550	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
2.1550	0.0	0.0	260.0	0.0	61.9	61.9	0		
2.1550	0.0	0.0	240.0	0.0	57.1	57.1	0		AIR
2.1550	0.0	0.0	200.0	0.0	47.4	47.4	0		AIR
2.1550	0.0	0.0	180.0	0.0	42.5	42.5	0		
2.1550	0.0	0.0	140.0	0.0	32.5	32.5	0		
2.1550	0.0	0.0	100.0	0.0	22.1	22.1	0		
2.1550	0.0	0.0	.0001	0.0	0.0	0.0	0		
4.6430	0.0	60.000004	356.38	670.0	7233.516	7233.516	1	C*	
4.6430	0.0	50.000004	355.06	640.0	7212.535	7212.535	1	C*	
4.6430	0.0	30.000004	349.99	610.0	7128.082	7128.082	1	C*	
4.6430	0.0	20.000004	344.02	730.0	7022.750	7022.750	1	C*	
4.6430	0.0	10.000004	327.57	030.0	6716.680	6716.680	1	C*	
4.6430	0.0	5.000004	298.52	730.0	6163.723	6163.723	1	C*	
4.6430	0.0	1.000004	137.70	310.0	3614.779	3614.779	1	C*	
4.6430	0.0	0.350003	895.82	470.0	1659.755	1659.755	1	C*	
4.6430	0.0	0.200003	545.32	010.0	793.749	793.749	1	C*	
4.6430	0.0	0.190003	450.85	520.0	703.942	703.942	1	C*	
4.6430	0.0	0.180003	247.23	140.0	577.170	577.170	1	C*	
4.6430	0.0	0.175002	587.24	220.0	336.718	336.718	1	C*	
4.6430	0.0	0.174902	446.85	180.0	292.211	292.211	1	C*	
4.6430	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
4.6430	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
4.6430	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
4.6430	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
4.6430	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
4.6430	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
4.6430	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
4.6430	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
4.6430	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
4.6430	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
4.6430	0.0	0.0	260.0	0.0	61.6	61.6	0		
4.6430	0.0	0.0	240.0	0.0	56.8	56.8	0		AIR
4.6430	0.0	0.0	200.0	0.0	47.0	47.0	0		AIR
4.6430	0.0	0.0	180.0	0.0	42.0	42.0	0		
4.6430	0.0	0.0	140.0	0.0	31.9	31.9	0		
4.6430	0.0	0.0	100.0	0.0	20.6	20.6	0		
4.6430	0.0	0.0	.0001	0.0	0.0	0.0	0		
10.0	0.0	60.000004	523.08	590.0	7287.566	7287.566	1	C*	C I
10.0	0.0	50.000004	521.64	840.0	7266.633	7266.633	1	C*	C I
10.0	0.0	30.000004	516.10	550.0	7182.422	7182.422	1	C*	C I
10.0	0.0	20.000004	509.58	200.0	7077.316	7077.316	1	C*	C I
10.0	0.0	10.000004	491.61	330.0	6771.469	6771.469	1	C*	C I
10.0	0.0	5.000004	462.62	500.0	6207.809	6207.809	1	C*	C I
10.0	0.0	1.000004	285.25	780.0	3644.154	3644.154	1	C*	C I
10.0	0.0	0.350004	018.12	600.0	1683.882	1683.882	1	C*	C I
10.0	0.0	0.200003	631.98	660.0	814.692	814.692	1	C*	C I
10.0	0.0	0.190003	528.03	880.0	723.283	723.283	1	C*	C I
10.0	0.0	0.180003	304.30	910.0	592.285	592.285	1	C*	C I
10.0	0.0	0.175002	560.63	530.0	328.083	328.083	1	C*	C I
10.0	0.0	0.174881	887.29	000.0	118.726	118.726	1	C*	C I
10.0	0.0	0.1748	1666.67	0.0	50.80	50.80	1	C*	
10.0	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
10.0	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
10.0	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
10.0	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
10.0	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
10.0	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
10.0	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
10.0	0.0	0.0	1000.0	0.0	250.1	250.1	0		AIR

10.0	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
10.0	0.0	0.0	260.0	0.0	61.4	61.4	0		
10.0	0.0	0.0	240.0	0.0	56.6	56.6	0		AIR
10.0	0.0	0.0	200.0	0.0	46.7	46.7	0		AIR
10.0	0.0	0.0	180.0	0.0	41.6	41.6	0		
10.0	0.0	0.0	140.0	0.0	31.2	31.2	0		
10.0	0.0	0.0	100.0	0.0	19.2	19.2	0		
10.0	0.0	0.0	.0001	0.0	0.0	0.0	0		
100.	0.0	70.000005	112.9258	0.0	7495.691	7495.691	1	C*	C I
100.	0.0	60.000005	111.5313	0.0	7480.984	7480.984	1	C*	C I
100.	0.0	50.000005	109.6098	0.0	7460.195	7460.195	1	C*	C I
100.	0.0	30.000005	102.2344	0.0	7376.570	7376.570	1	C*	C I
100.	0.0	20.000005	093.5430	0.0	7271.852	7271.852	1	C*	C I
100.	0.0	10.000005	069.6758	0.0	6965.836	6965.836	1	C*	C I
100.	0.0	5.000005	027.7305	0.0	6409.297	6409.297	1	C*	C* I
100.	0.0	1.000004	796.4336	0.0	3819.462	3819.462	1	C*	C* I
100.	0.0	0.350004	446.3047	0.0	1813.295	1813.295	1	C*	C* I
100.	0.0	0.200003	926.8440	0.0	899.137	899.137	1	C*	C* I
100.	0.0	0.190003	785.4890	0.0	797.616	797.616	1	C*	C* I
100.	0.0	0.180003	487.0220	0.0	646.633	646.633	1	C*	C* I
100.	0.0	0.175002	627.8584	0.0	348.924	348.924	1	C*	C* I
100.	0.0	0.174842	179.8745	0.0	208.590	208.590	1	C*	C* I
100.	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
100.	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
100.	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
100.	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
100.	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
100.	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
100.	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
100.	0.0	0.0	1000.0	0.0	251.4	251.4	0		AIR
100.	0.0	0.0	500.0	0.0	119.2	119.2	0		AIR
100.	0.0	0.0	260.0	0.0	55.4	55.4	0		
100.	0.0	0.0	240.0	0.0	49.3	49.3	0		AIR
100.	0.0	0.0	200.0	0.0	35.1	35.1	0		AIR
100.	0.0	0.0	180.0	0.0	25.4	25.4	0		
100.	0.0	0.0	140.0	0.0	17.1	17.1	0		
100.	0.0	0.0	100.0	0	9.8	9.8	0		
100.	0.0	0.0	.0001	0.0	0.0	0.0	0		



New line of data must be included.

APPENDIX E

PUTZ AND BARTLETT CORRELATION FOR GRAPHITE ABLATION

APPENDIX E

Putz and Bartlett Correlation for Graphite Ablation

$$q_w = \psi(\rho_e u_e C_{H_o})(H_r - h_w) , \tag{E.1}$$

$$\dot{m} = (\rho_e u_e C_m)\beta' , \tag{E.2}$$

$$\frac{C_M}{C_{H_o}} = \frac{\phi_m}{e^{\phi_m} - 1} , \tag{E.3}$$

$$\phi_m = 2\lambda_m \beta_o' , \tag{E.4}$$

$$\lambda_m = (1.012 + 0.018\beta_o' + 0.0814\beta_o'^{\,2})(1.0 - F_1) , \tag{E.5}$$

$$F_1 = (0.238 + 0.038\beta_o')\left(\frac{F_2 - 0.95}{0.60}\right)^{0.71} , \tag{E.6}$$

$$F_2 = \begin{cases} 0.95, & M_w/M_e \le 0.95 \\ M_w/M_e, & 0.95 < M_w/M_e < 1.55 \\ 1.55, & M_w/M_e \ge 1.55, \end{cases} \tag{E.7}$$

$$\psi = 1.0 - 0.6563\beta_o' + 0.01794\beta_o'^{\,2} + 0.96365\beta_o'^{\,3} - 0.01125\beta_o'^{\,4} \tag{E.8}$$

where

q_w = surface convective heat flux,

$\rho_e u_e C_{H_o}$ = nonablating heat transfer coefficient evaluated at the wall surface temperature,

H_r = recover enthalpy,

ψ = heat transfer correlation parameter C_H/C_{H_o},

h_w = static enthalpy evaluated at wall (surface),

C_M = mass transfer coefficient,

λ_m = mass transfer correlation parameter,

β' = $m_w/\rho_e u_e C_M$, mass loss parameter,

β_o' = $m_w/\rho_e u_e C_{H_o}$,

M_w = molecular weight of gases at wall (surface),

M_e = molecular weight of gases at edge of boundary layer,

m_w = mass loss rate per unit area at wall (surface).

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